INDUSTRIAL ENGINEER

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Aweel, It's Aboot So

For ye've seen it yersel' and ye ken it as wull as me.

HERE IS a letter that I have received from my good friend Victor Orth of Gardenville, N. Y.

"Why on earth has it been and still is necessary in most plants for the maintenance electrician to keep his eyes well peeled when new work is being installed by construction gangs? It happens too frequently that he is required to take care of motors and starters in such places that an acrobat cannot reach them without tearing the works down. In such cases it is no wonder that he shows considerable irritation when he hears the engineering department's ballyhoo explain to the boss how neat and compact the whole outfit is, and make such remarks as: 'Don't you see, the motors and switches are all out of the way, and cannot be harmed or do harm?'

"I am not usually revengeful, but I would like to see some of these men tear down platforms of two-inch stuff to be able to get at a motor and then rebuild them. I have seen compensators whose fingers had to be frequently inspected put so close to a wall that I had to tie myself into a knot and try to get at them with a home-made off-set screw driver and much sulphurous language. The reason for these particular starters being so placed was to accommodate the width of the trucks being used, while but a few feet away there was plenty of spare room. Many times I have seen switches and motors set where there was sure to be drippings from pipes and condensation from steam, with no way to entirely protect them, when better locations were feasible. Other examples are panel boxes bolted close to the wall with fuse blocks bolted with nuts at the back so that in case of a grounded block there was no way of getting at the nut, and to make a replacement it was necessary to break the porcelain and cut the bolts with a cold chisel. Anyone who has tried that knows what size screws he is likely to need for the new block. Why not tap the box out in the first place and use brass screws?

"Are the engineers and layout men in our plants too proud to consult with the men who do their darndest to make their installations perform the work they were meant to do? Are they afraid to appear ignorant or uninformed? They need not be. Maintenance is a thing apart from the usual training of office and technical men. They cannot have the experience nor the chance of watching the results and behavior of installations as the maintenance man sees them, nor for so long a time, nor under all the different conditions of service. An experienced maintenance man can tell the man above plenty of things that would be of value to him, but most of them will not unbend to listen, much less ask. Can anyone suggest a reason and how to overcome this situation?"

Mr. Orth has said a mouthful and given us something to think about. Let's not let the matter drop here but write me how you have handled the situations he brings up.

Practical Pete

A Glimpse Into the Operations in

Packingtown, Union Stock Yards, Chicago

Within an area about a mile square, a portion of which is shown below, the world's largest meat packing center has been built up. This is the fifth of a series devoted to the growth and extent of basic American industries.

ON AN average over 45,000,000 lb. of meat are consumed in the United States daily. Over two-thirds of this is raised west of the Mississippi River and consumed east of it. The big problem in connection with the packing industry is that meat is perishable and may at any minute become a total loss on the trip from the ranges to the dinner tables of our cities. When viewed strictly from the handling of meat as a food product, the packing business is an enormous industry. Around it, however, have grown extensive associated industries and specialized manufacturing processes that produce hundreds of byproducts used in almost every industry.

The beef from this Texas ranch may have been served on your own dinner table, after passing through one of the many packing centers in the United States.

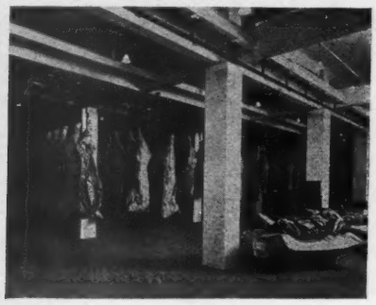
The census of 1919 shows about 50 packing companies in Chicago. Chicago early became a meat-packing center. Most of the early slaughtering was for local consumption, but in 1832, 152 head of cattle were slaughtered and shipped by boat to New York.

An airplane view of a part of Packingtown and Union Stock Yards.

A list of some of the principal buildings and divisions shown indicate the extensive operations of a packing organization, as: (1) office of Armour & Co.; (2) office of Swift & Co.; (3) plant and office of Libby, McNeill & Libby; (4) Swift's soap factory; (5) Swift's oleomargarine plant; (6) power plant and car shops of Swift & Co.; (7) cattle killing and coolers, Swift & Co.; (8) hog killing and pork warehouse, Swift & Co.; (9) sausage and lard manufacturing division, Swift & Co.; (10) hog killing and pork warehouse, Morris & Co.; (11) cold storage warehouse, Armour & Co.; (12) wholesale market, beef killing and cooling department, sheep killing and sheep coolers, Armour & Co.; (13) freezer building; (14) power house; (15) lard refining, Armour & Co.; (16) hog killing and cutting, Armour & Co.; (17) time-keeping department, printing plant, stationery and pepsin factory, Armour & Co.; (18) oleomargarine works, Armour & Co.; (19) Armour's freezer building; (20) wool house, Armour & Co.; (21) general storage; (22) fertilizer and albumin plant, Armour & Co.; (23) glue plant; (24) several small packing companies; (25) G. H. Hammond Packing Co.; (26) Armour car shops; (27) main plant of Morris & Co.

Due to the large number of killings pharmaceutical supplies have become a very valuable by-product. In some cases it requires 5,000 steers to produce one pound.

Pressing oleo oil from beef-kidney fat. Stearine remains in the cloth bags between the presses.



Fresh beef must be kept at a temperature of 38 deg. and must be disposed of within two weeks.

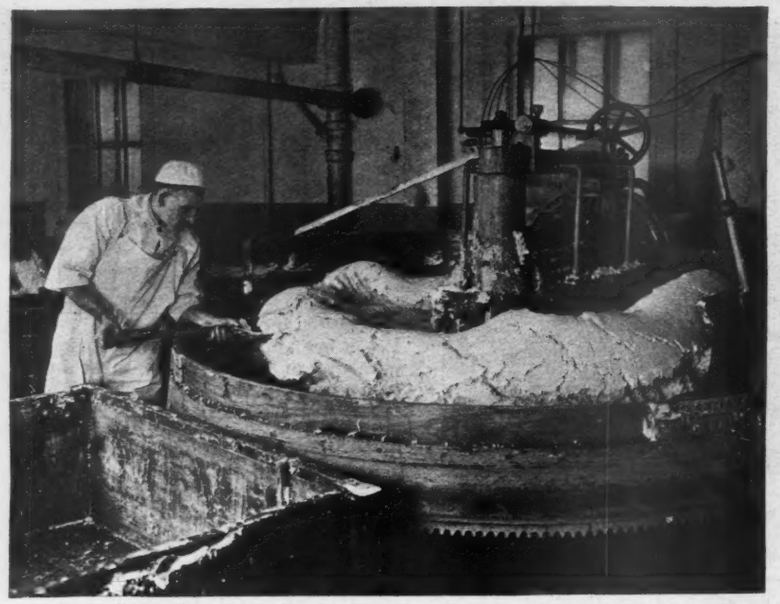
On Christmas Day, 1864, the present Union Stock Yards was opened. This now consists of about 475 acres of pens and yards with a capacity for receiving and caring for 75,000 cattle, 300,000 hogs, 60,000 sheep and 6,000 horses. The "Yards" is a separate organization, not owned or controlled by any of the packing companies. During 1922 about 16,000,000 head of cattle, hogs and sheep were received in Chicago. About 12,000,000 were slaughtered and the remainder shipped elsewhere.

Packingtown is made up of the various packing companies which surround the "Yards" and receive their live stock supplies from it. Here is located one-seventh of an entire industry which in value of product is the largest single industry in Chicago and also in the United States. According to the 1919 United States census report the value of the products of slaughtering and meat-packing industries in the United States was $4,246,290,000. About $3,774,901,000, or 89 per cent was paid for raw material, mostly live stock.

Originally, slaughtering was mostly done locally, to supply fresh meat for home consumption or to be pickled or otherwise cured for the summer or for shipping. About 1890 the packing companies took up and developed the application of mechanical refrigeration. Meat goes into mechanically refrigerated coolers, where it is chilled, because fresh meat deteriorates rapidly unless the animal heat is removed quickly. Care must be taken that it is not frozen, or if so, it must remain frozen until used. After they are killed and dressed, hogs are kept at 38 deg. for 48 hours before they are cut up into sides, hams, and so on. Fresh beef is also kept at 38 deg. but cannot be kept in storage for over two weeks.

There are many peculiarities incidental to the packing business which are radically different from conditions found in many other industries: from 85 to 89 per cent of the selling price is expended for raw material, which leaves only a narrow margin for cost of manufacturing, transportation and distribution to retail butcher shops. The packers pay cash and sell on time. Some companies each pay out over $1,000,000 a day for live stock. Too, the packers buy live and sell dressed. A 1,000-lb. steer will dress only about 550 lb. of beef, and a 250-lb. hog only about 185 lb. of pork. A dressed lamb is only about 50 per cent of its live weight. Also, the cuts which are in greatest demand are only a small percentage of the whole animal. Some of these cuts sell at a relatively higher price and other parts of the animal which are less in demand must, of course, sell at a lower figure to be sold at all.

One of the valuable by-products of the industry is the hides of the beeves. These must be removed very carefully and inspected as any holes cut into the hide decreases its value. Note on the butcher's hip the sheath for his knife.



Here the oleomargarine is "worked," that is, the granules are kneaded together, the necessary amount of salt is worked in and the excessive moisture worked out. The trucks and machines are sterilized with live steam daily.

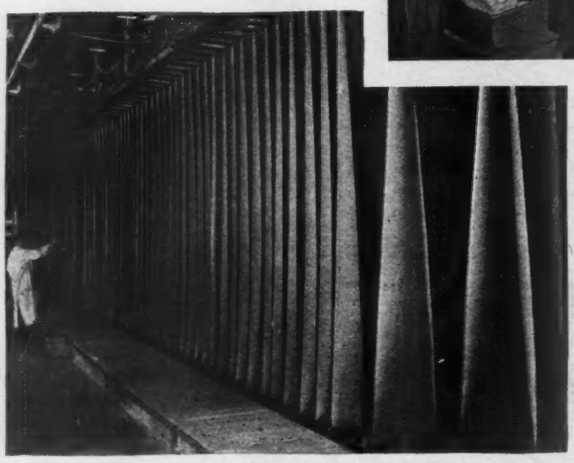
Also there is a wide variety of grades of meat; for example, there are twenty-seven grades of beef, each of which commands a different wholesale price.

An old saying is that the packing houses use everything but the pig's squeal. However, much cannot be recovered; for example, in a 1,000-lb. beef 30 per cent or 300 lb. is water. The most valuable byproducts are the fats, beef hides, sheep hides and wool. The excess fats are worked up into soap and oleo for oleomargarine; the hides are disposed of to tanneries and the wool to woolen mills. Other inedible byproducts are other fats which are made into inedible oils, tallow, bone, horns, and fertilizer made from otherwise unusable parts.

Because of the large amount of these byproducts on hand the packing companies have been forced to develop organizations which would not only make these up into finished products but also promote the sale of them. For this reason they have developed many side lines, such as cleaning powders; curled hair for upholstering; brushes; glue from bones and horns; case-hardening material and novelties from bone; animal feed and albumin, from which is made a weatherproof glue, from blood; sausage containers, gold beater's skins, parchment, violin strings and other products from casings; pharmaceutical products from various glands and organs of the animals, and fertilizer from the miscellaneous left-over materials not usable in any other way. In using these up the packing companies have been forced to go so far as to use the glue in making sandpaper, to make buttons from the bones, and many other products which on the surface might appear as in no way related to the packing industry. In this way the industry has developed many lesser industries. Nearly every one of the larger packing organizations has its individual soap works, oleomargarine plants, fertilizer plants, glue works, and so on, in addition to the packing plant proper.

The Editors desire to acknowledge the assistance of the Institute of American Meat Packers in the preparation of this article.

Soap, one of the big byproducts of the packing industry, is being cut into bars and stamped with the trademark name, in the illustration at the right. Below is shown the sandpaper drying room, where one packing organization uses much of its excess glue.



One of the steps in making curled hair for upholstering is to twist it up into these ropes.

WITHOUT EFFICIENT and systematic inspection and care, dependable service from motors and other electrical equipment is, in most cases, exceptional. In this article Mr Knowlton shows how definite placing of the responsibility for maintenance work in the plant of the Dennison Manufacturing Co., has greatly reduced interruptions of service, increased production and prevented fires caused by defective equipment.

Here Are Some

Results of Thorough Inspections

And How Increased Production and a Marked Reduction in Operating Troubles Have Followed

Besides thorough inspection of equipment, adequate guards and brackets on motors are provided to prevent belts flying off and injuring operators.

By H. S. KNOWLTON

Contributing Editor, Industrial Engineer

FOR many years works engineering has received constant and thorough attention at the factory of the Dennison Manufacturing Company, Framingham, Mass. This company manufactures upwards of 2,000 different products, including tags and paper specialties in great variety. From small beginnings about three-quarters of a century ago, the company has expanded until it now occupies a number of large buildings and employs about 2,500 persons. The problems of electrical service maintenance have become of increasing importance as the years have passed, and through the courtesy and the assistance of the company, the writer has been enabled to compile this account of some of the more recent electrical betterment work looking toward the maintenance of continuous production as it is carried out in this plant.

Nearly 800 electric motors are in service, ranging in size from 75 hp. to 1/16 hp., with a total rating of about 1500 hp. Most of these motors are of the direct-current type, and about half are of the variable-speed type. Although in all commercial factories sustained production is important, it is particularly so in a plant making the variety of products here concerned, with productive departments extending over considerable areas and with raw material consuming large quantities of paper and cardboard stock with their incidental requirements of cleanliness in processes and fire protection throughout the establishment.

During the past year the inspection of motors, wiring and control equipment has been made more definite and regular through the assignment of one man to this particular detailed service. Formerly the company's chief electrician endeavored personally to inspect all motors as regularly as possible. But it was decided some months ago to place the immediate responsibility for this work upon an electrical maintenance staff to insure a greater degree of preventive inspection than was possible under the old arrangement. As a result the time lost from motor and control failures has been substantially reduced, and in one department where occasional slight fires had occurred from the ignition of lint by sparks from commutators or other causes, not a single fire has taken place since the inauguration of the new inspection system. It is stated by representatives of the company that the assignment of one man to the inspection of motors, control and wiring, has unquestionably paid for itself in decreased operating troubles and better sus-

Fig. 1—This typewritten form is given to the inspector. He checks his inspection on each machine and makes note of any repairs that are necessary.

Date.....

The following list of motors and controllers to be thoroughly cleaned and necessary repairs made in Dept. 21, 9-2-3; and Dept. 25, 9-2-3.

MOTOR#	CONTROLLER #	MACHINE #	REMARKS #
5158	3734	1305 Blower	
4811	No controller	4637	
4747	4748	4731	
769	3008	Main for color room	

Return this sheet to Dept. 22 when finished.

SIGNED.....

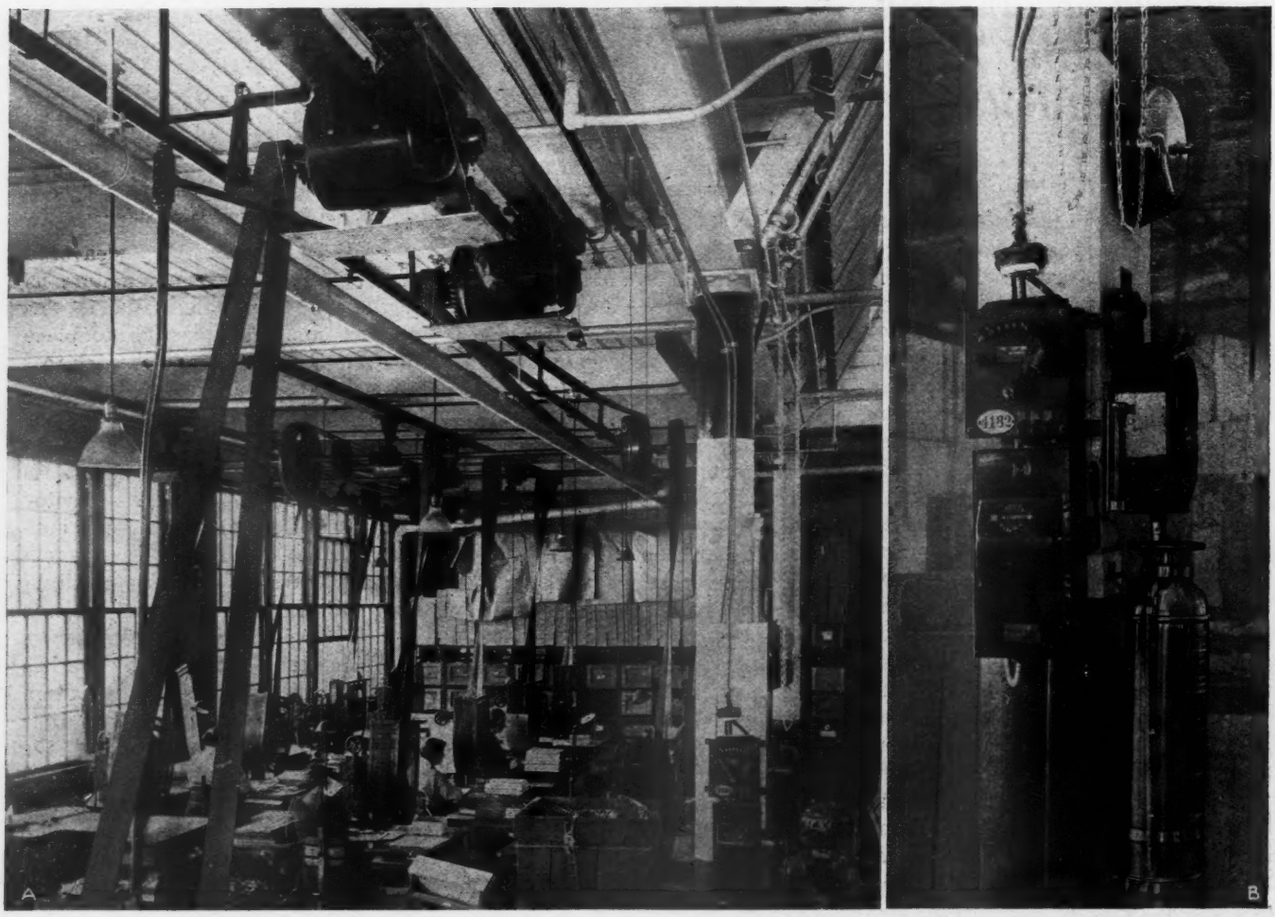
tained production in the departments.

Depending upon the class of service required of a motor, all motors now receive a thorough inspection at least every three months and in many cases monthly. The motor inspector's hours are somewhat different from the regular factory hours so that he may do part of his work when machinery is shut down. When he starts on an inspection trip, a letter-sized typewritten sheet or maintenance work-order (Fig. 1) is handed to him, directing him to clean and make all necessary repairs on motors and controllers in a specific department. Each motor, controller and machine concerned in the inspection is listed on the sheet with the company's number. Space is provided for the notation by the inspector of any remarks bearing upon his findings and work done at the time of the inspection. A check mark is entered opposite the equipment requiring no repair work. This work sheet or field report is turned into the electrical department with the completion of the work on the equipment listed. If shop repairs are required and a motor has to be removed from its location and rewound, a separate work order is prepared to cover this work.

This arrangement of work sheet to cover inspection minimizes the amount of clerical service which must be performed in connection with the inspection of motors and control apparatus, and therefore is applicable to motor inspection routine in other industries. The reduction of clerical work by inspectors and maintenance men to the minimum possible is looked upon as vital to the success of such a system in a busy plant.

Fig. 2—Note the grouping of fire-alarm, watchman's box, etc., and control in one location.

At the right is a group drive for twelve presses. On the column shown enlarged at the right are mounted the fire-alarm box and gong, watchman's box, thermometer and control for a nearby motor, all in one place.



ELECTRICAL MAINTENANCE

1½ HP MOTOR # 5390 CONTROLLER # 5426 MACH. # 5389

DEPT. 10 BLDG. 4 SEC. 1 FL. 2

DATE	INSPECTION REPORTS	DISPOSITION
5/19/22	New Mach. additional light needed	Order sent to 12A
11/23/22	Cleaned motor and control	
	Replaced one brush	

Fig. 3—Record cards like this are kept in file for each motor. Work done on a machine is noted on this card.

In the electrical department a card record (Fig. 3) is maintained showing the date, inspection results and action taken upon every motor and associated piece of control equipment. The card is filed according to the motor rating and the factory numbers of motor and control apparatus, the location of the equipment also being stated on the card.

It has not been found necessary to prepare a detailed inspection sheet specifying every step to be taken in the inspection of a motor and its control. This routine is left to the inspector, who was trained to care for it when the change was made to the present system. The motor inspection, however, includes examination of bearings, commutators, brushes, wear of bars and brushes, condition of brush-holder as regards binding, whether oil rings turn or not, adequacy of oil supply, condition of wiring and contacts, cleanliness of motor and condition as regards heating. Usually motors are blown out by compressed air on these inspections, a portable compressor being available for the use of the inspector.

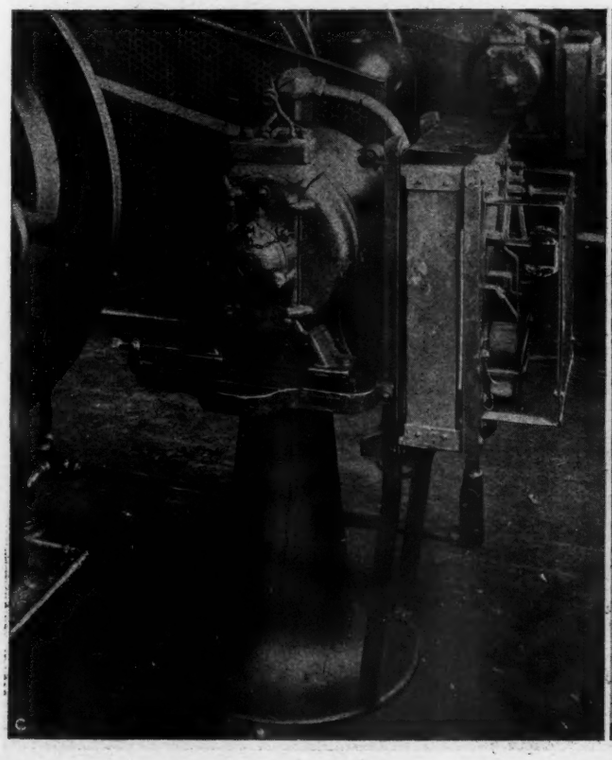
Control equipment is examined for indications of loose contacts, frayed insulation on wiring, operating temperature, condition of contacts and indications of flashing. The control equipment is also blown out with air at the same time the motor inspection is made. A test of the controller's ability to function normally is also made during the inspection, and it is under consideration to check up regularly the size of fuses in use on motors and to report these to the electrical department.

Inspection of motor and control apparatus normally begins at 7 a. m., or about 45 minutes before the plant starts regular production. This is continued until 11:30 a. m., and resumed at 12:30 p. m., the half-hour until 1 p. m. being devoted usually to odd jobs on electrical equipment which can be more conveniently performed while the machinery is not in operation. The afternoon is devoted to further inspection and repair work on the installed equipment, and unless emergencies require it, the inspection work ceases at 4:45 p. m. It has been found that many small jobs can be done during the periods of factory shut-down in early morning and at noon, which would require more or less interruption of production processes if handled during the middle of the forenoon or afternoon.

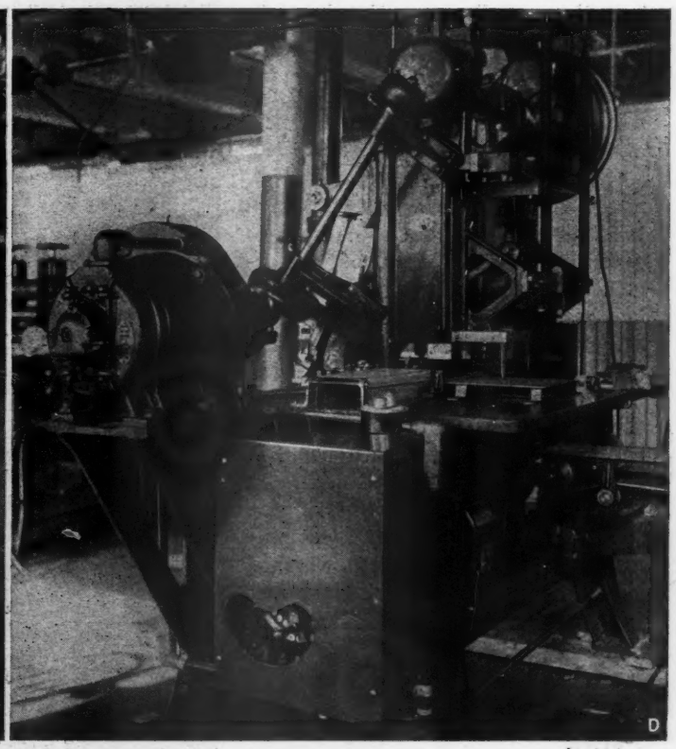
Recently particular attention has been paid to the maintenance of spare equipment and parts as a factor in assuring quick repairs. Up to and including about 35 hp., it is planned to keep on hand at least one extra motor of each leading size, so that if a breakdown occurs in the factory, prompt replacement can be effected while permanent repairs are made. About twenty-five spare mo-

Fig. 4—Two good examples of individual drive.

At the left is a drive for a job press with motor and control mounted on one pedestal. A bracket fastened at one end of the machine supports the motor at the right. Notice how both of the control panels are amply protected from injury by sheet-iron plates.



C



D

tors are on hand, and these are of course available for use in pairs or otherwise if necessary to attain a particular rating in driving for emergency service. It is the aim of the electrical department to keep on hand one set of extra bearings for at least every size of motor, and similarly, extra sets of brushes, contacts, solenoid switches, etc. It is considered better practice to carry a few extra sets of brushes than to fall back upon cutting down brushes to size with a hack-saw in case of a shortage of a particular size.

Another step in the direction of saving time on repair work has been the decision to do the rewinding of motors and other apparatus in the factory instead of sending the equipment outside. This has been done now for some months past, and with a decided reduction in the time required to get a motor into condition for re-installation. During periods when the amount of motor winding is small, the winder who is engaged on this work is assigned to making special coils for heating service or other applications. A total of ten men, including the motor inspector and the armature winder, are employed in maintenance work of an electrical character in this plant.

A very important section of the electrical equipment in this factory is the automatic interior telephone system used at Framingham. Reliability of service is so important here that a daily inspection is made of the automatic telephone equipment. The results are indicated on a form (Fig. 6) showing line-switch tests on different numbered circuits, and the functioning of batteries, signals, and other equipment. A monthly inspection is also made of the automatic telephone equipment and the condition of motor-generator brushes, ringing machine brushes, commutator conditions, lubrication conditions and other points are noted. The monthly inspection is recorded on a sheet covering all the major points for which the inspectors look. Special attention is paid to checking off the lubrication of important parts of the moving switch mechanism which selects the called numbers. This form, which is shown in the accompanying table, is an excellent guide for the inspector. It lists the various things he must do. As he must check off each item on the form, it keeps him from forgetting any points. This telephone inspection is a highly specialized task and it is normally handled alternatively by two inspectors specially trained to handle these details. This arrangement insures adequate inspection under varying conditions. The system has resulted in a much more reliable telephone service within the factory.

In its earlier days, the Dennison factory was chiefly a group-driven installation, but within the last ten years the use of individual motors has greatly increased, and the tendency is gradually toward the elimination of the group drive. In many departments the advantages of being able to maintain production regardless of the interruption of service at a single motor, the increased cleanliness of individual driving, and the more flexible speed control secured by separate machine powering, are controlling arguments for the change. Along with the increasing use of individual motor drives has gone a careful study of the plant from the standpoint of safety engineering, and the installations embody an unusual degree of protection, both to the employe and to the apparatus.

In the following illustrations of typical improved drives adopted at the Dennison plant, it will be noted that the use of rigid or flexible armored conduit is general. The location of control equipment is out of the way of passers-by or else protection against contact has been afforded, and the use of push-button types of control has been very widely applied. It is interesting to note that since the use of individual motor drives became general in the plant, it has become possible for two belt-maintenance men to inspect (every three months) all the belts in the factory during the noon hour.

Fig. 5—Saving of space and protection of the operator from injury characterize this method of mounting the motor for individual drive.

The mounting of the motors on machines formerly driven off line shafts by belts has been facilitated by the wide use of angle-iron and strap-iron brackets formed or selected on the premises, and motors in general are located conveniently for both inspection and light repair work.

A well-arranged but now passing type of installation is illustrated in Fig. 2 which shows a group drive of a dozen Perkins presses. A 3-hp. motor mounted on two hard-pine ceiling beams drives a shaft from which the group is in turn operated. This particular drive is a well-segregated group, but in case of motor trouble all twelve machines are down. There is more or less obstruction caused by the overhead belting, and conditions in general are inferior to the direct belt drive which is used in the same department.

Similar types of machines are driven through an individual belt by a 1-hp., 1200-r.p.m. motor mounted on 4-in. by 6-in. hard-pine ceiling timbers, with flywheel and belt guard at the machine level. The wiring is carried to the motor in rigid conduit run vertically from the floor, and a starting and stopping switch is placed within easy reach of the operator. The contactor switches required in connection with the push-button control used here are mounted behind protective screening supported by 1¼-in. by ½-in. strap-iron. A U-shaped belt hook at the side of the motor protects the operator and others in case a belt should slip off the motor pulley. The independence of these drives is in striking contrast to the former group system.

Two good individual drives are shown in Fig. 4. A compact mounting of motor and control equipment is shown at *C*, this being a job-press motor (*Continued on page 261*)

MONTHLY INSPECTION OF AUTOMATIC TELEPHONE EQUIPMENT

Clean, Oil and Inspect the Equipment Mentioned Below

POWER EQUIPMENT

Question	Yes or No	Remarks
Motor Generator Starting Operation Satisfactory?	.....	.....
Motor Generator Brushes Worn Normally?	.....	.....
Motor Generator Commutator Clean?	.....	.....
Circuit Breaker Operation Satisfactory?	.....	.....
Motor Generator Oiled With Medium Motor Oil?	.....	.....
Change Ringing Machines?	.....	.....
Ringing Machine Brushes Worn Normally?	.....	.....
Ringing Machine Spring Adjustment O. K.?	.....	.....
Ringing Machine Commutator Worn Normally?	.....	.....
Ringing Machine Commutator Clean?	.....	.....
Solenoid Charging Switch Operation Satisfactory?	.....	.....
Ringing Machine Bearings Oiled With Light Engine Oil?	.....	.....
Ringing Machine Worm Drive Oiled With Oildag?	.....	.....
Notes		

MASTERSWITCH EQUIPMENT

Question	Yes or No	Remarks
Governor Work Oiled With Clock Oil?	.....	.....
Governor Bearing Oiled With Clock Oil?	.....	.....
Driving Segment Oiled With Oildag?	.....	.....
Control Segment Oiled With Oildag?	.....	.....
Locking Armature Pivots Oiled With Oildag?	.....	.....
Locking Relay Armature Pivots Oiled With Oildag?	.....	.....
Solenoid Plunger Bearing Oiled With Oildag?	.....	.....
Main Shaft Bearing Oiled With Oildag?	.....	.....
Connecting Link Oiled With Oildag?	.....	.....

SELECTOR AND CONNECTOR EQUIPMENT

Question	Yes or No	Remarks
Shaft Bearings Oiled With Oildag?	.....	.....
V. & N. Ratchet Oiled With Oildag?	.....	.....
V. & H. Pawl uides Oiled With Oildag?	.....	.....
D. D. Bearings Oiled With Oildag?	.....	.....
Spider Bearings Oiled With Oildag (Armature)?	.....	.....
Escapement Oiled With Oildag?	.....	.....

Notes .....

Date..... .....Inspected by.....

Fig. 6—Daily inspection of automatic telephones is recorded on this sheet.

A monthly inspection also is made in accordance with the table which is shown at the left of this sheet.

JOB #.....

DAILY INSPECTION OF AUTOMATIC TELEPHONE EQUIPMENT.

LINESWITCH PLUNGE-IN TEST	NO.	200 BOARD 1	2	3	4	5	6	7	8	9	10	300 BOARD 1	2	3	4	5	6	7	8	9	10
TWO GROUPS OF EIGHT CONSECUTIVE NUMBERS ON EACH BOARD TO BE TESTED ON ALL TRUNKS	301	✓							×												
	302		✓																		
	303			✓																	
	226						×														
CONNECTOR TESTS																					
SELECTOR TEST																					

NOTES Lineswitch 226

TESTS	YES	NO	REMARKS
BATTERY VOLTAGE O. K.			
LINESWITCH GUARD SIGNAL O. K.			
FUSE ALARM SIGNAL O. K.			
RELEASE SIGNAL O. K.			
M. D. F. SIGNAL O. K.			
MASTER SWITCH SPEED O. K.			
MASTER SWITCH ALARM O. K.			
RINGING GEN & BUSY O. K.			
M. B. & O. M. CROSSED			

NOTES

DATE..... INSPECTED BY .....

Here a large conveyor belt is being connected by an "Alligator" flexible lacing. A job like this requires heavy belt clamps.

Some Hows and Whys of

Servicing Industrial Belts

So as to Eliminate Time Losses, Reduce Belt Trouble and Give Information for Selecting the Right Belt

By FRANK E. GOODING
Associate Editor, Industrial Engineer

GOOD belt service is no accident. It is only when belts are chosen with the idea of getting the proper belt for the conditions under which it operates that ordinary troubles which are connected with belt service are eliminated. However, in any case belts require some attention. Ordinarily, the operation of lacing a belt is an item of small expense; the big items of expense are an idle machine and the time of the operator, both of which are lost while the belt receives attention. A good belt man can do much to reduce the amount of idle time connected with repairing belts. Practically every machine is idle at some period, such as when changing jobs, making adjustments or other similar work. A belt man who knows that a belt is giving way can, before it has come to the point where it interferes seriously with production and forces a change, plan to do the necessary work during these idle periods. In one plant, for example, the belt man, in his inspections around the plant, locates the belts which are giving way and fixes them during the noon hour, when the work does not interfere with production. He takes his own noon hour at a different time from the rest of the plant.

ALTOGETHER too often it is only when belts give trouble that they receive any attention. However, belt difficulties, like many other shop troubles, may be anticipated and frequently decreased, if not prevented, by proper servicing as explained in this article.

As mentioned, the larger proportion of the work in connection with servicing belts consists of joining them. In general there are three methods for doing this: A belt may be connected by flexible lacings, rigid connections, or by splicing endless.

The most common type of flexible

lacing is by rawhide. Practically every belt man has his own preference as to ways of lacing, but several of the various methods which have worked satisfactorily are shown, in the illustration on page 240. In making rawhide lacings care must be taken so that too much of the cross-section of a belt is not punched out by the holes. Also holes should not be too near the edge or end of the belt and should be even and line up. It is also advisable that the lacing run lengthwise of the belt on the side which faces the pulley. A rawhide lacing, properly made, is very effective in its operation over a pulley.

Manufacturers of fabric belting seldom recommend the use of rawhide lacing because punching the holes with the ordinary belt punch cuts the fabric. Where rawhide lacing is used it is best to punch holes in the fabric belt with an awl instead of cutting with a punch, as is ordinarily done with leather belt. Soft wire lacings are also used very frequently for joining belts. One advantage of this is that it does not require as large a hole as does a rawhide lacing. A disadvantage lies in that in case one strand of the wire lacing should break it leaves a dangerous sharp point which is liable to catch on the clothing of those who work near the moving belt.

Some of the various types of hinged flexible lacings are used in many plants. One of the chief advantages of these is that they can be applied very quickly. With these lacings it is not necessary to punch holes but only to see that the belt is cut square and the lacing is applied square. Various methods are used for applying the different types of these lacings, such as special machines, clamping in vises, a hammer, and other methods. These operate very satisfactorily if care is exercised in putting them on properly. Examples of these lacings properly and improperly applied are shown on page 238. They give flexible joints for passing over pulleys and may be used over pulleys of small diameter and in connection with idlers.

A method of attaching a fastener to the end of a belt without sacrificing in some degree one or more of its qualities, such as strength, flexibility or thickness, has not been invented. The principal one to suffer has been the strength of the belt itself.

Nine tools which any belt man will find useful.

Although these nine tools are not all that a belt man could use, he will find these, listed by the Chicago Belting Company, convenient. They are: (1) Splitting gage; (2) belt knife; (3) glue brush; (4) turning steel; (5) tape; (6) heeler; (7) scraper; (8) finger steels; (9) screw driver. Other tools which will be necessary are belt clamps and presses and glue pots.

Since wire lacing came into use, it has been argued by some that the belt fibres are simply spread by the wire and the belt strength not impaired. Actual experience, however, does not support this theory for belts, particularly thin ones, frequently tear off through the line of perforations, which would not be the case if the belt strength had not been weakened. One manufacturer claims that the solution of this is to zigzag or stagger the perforations of the belt so as to get as few as practical in a straight line, and these as far apart in each direction as possible.

In the hook type of lacing an important factor is the angle at which the points enter the belt. Failure of the joint is usually due to the hooks lifting or pulling out. It is evident that there is an angle of penetration at which the resultant pull on the hook will be equally divided between the leg and the joint and any tendency to lift be neutralized, and it is, therefore, desirable to approximate this angle in practice as closely as possible. For this reason hooks too small for a belt do not clinch properly or get this best angle.

Crystallization is frequently referred to as an objection to wire lacing. Actual experience, however, proves that breakage from this cause is the exception rather than the rule, and it is a fairly well established fact that when it does occur, it is due to the use of too large or too heavy a hook. Wire will stand reversal of strains or bending within its elastic limit without damage for an indefinite period, but if large heavy hooks are put into a thin belt running at high speed over small diameter pulleys, crystallization may be, and should be expected.

The principal cause of breakage of hooks, however, is from wear and it is of the utmost importance in securing satisfactory results, that the wires be imbedded in the surface of

No _____

BELT RECORD CARD

Chas. A. Schieren Belt Record System

PLANT	DEPT	DRIVE of MACHINE

DRIVE		BELT
Driver	Diam x Face	Width
	R P M.	Tape Length
Driven	Diam x Face	Ply
	R P M'	Brand
Center Distance		Manufacturer
H P		Date Installed
Angle Drive		Date Taken Off
Open or Crossed		First Cost Belt
Tight Side		Maintenance Cost
Shifted		Total Cost Belt
Surrounding Conditions		Length Life
		Cost Per Foot Per Year

Remarks

Inspection Date:	Work Done	Date Tightened	Amount Taken Out	Time Required	Maintenance Cost

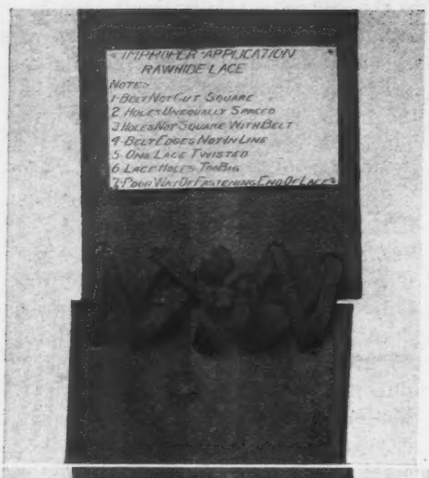
(Over)

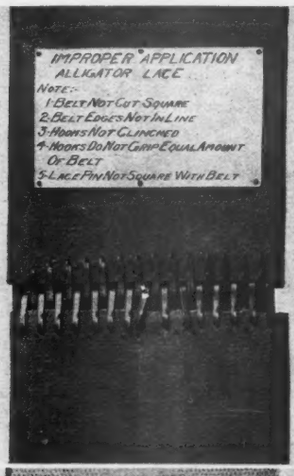
Without some record such as this card the belt user can only guess at the service his belt is giving.

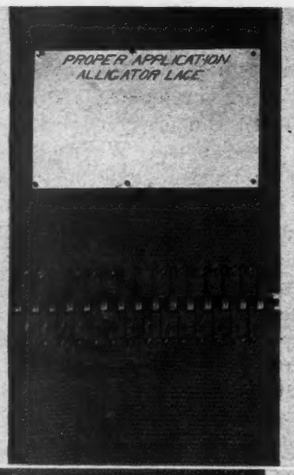
When the record card shows that a belt is causing an excessive amount of trouble and requiring too much maintenance, it is worth investigating to see whether the proper belt is used for the work. Additional entries are made on the back of this card. This is used by the Charles A. Schieren Company.

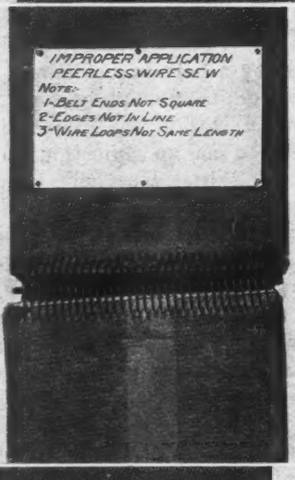
Proper and Improper Applications of Belt Fasteners

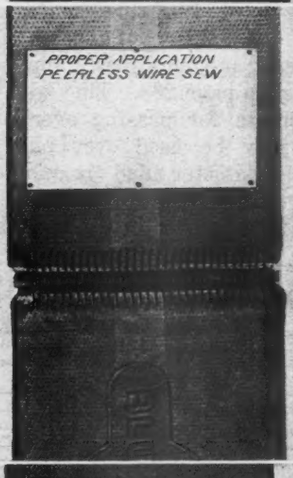
Any belt man who is proud of his ability as a mechanic would be ashamed to leave such evidence of his poor workmanship as is shown in some of the illustrations reproduced here by courtesy of The Goodyear Tire and Rubber Company. These companion pictures emphasize by contrast. The card on each belt indicates what was done wrong. Practically all of the shortcomings could be summarized in the one word—carelessness. Each of these fasteners operates satisfactorily if the right size is applied properly.



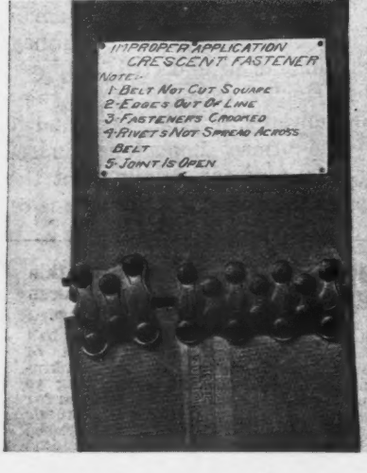


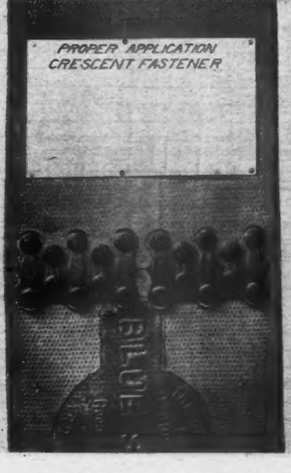


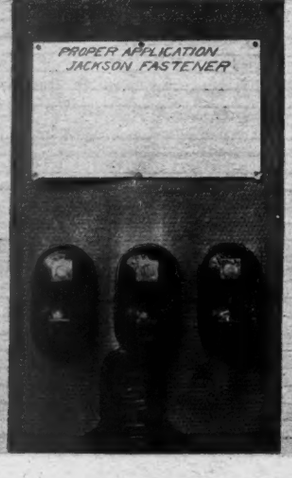




IMPROPER APPLICATION
JACKSON FASTENER
NOTE:-
1-BELT NOT CUT SQUARE
2-EDGES OF BELT OUT OF LINE
3-UNDER WASHERS NOT SET STRAIGHT ACROSS BELT
4-FASTENERS NOT SET STRAIGHT
5-BOLTS NOT PULLED TIGHT INTO BELT



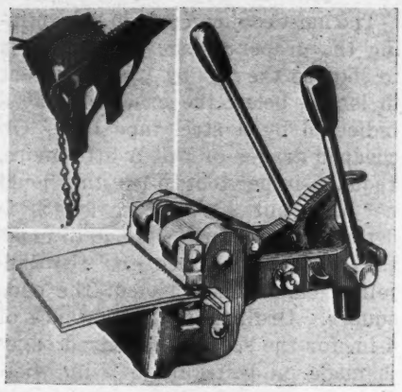




the belt sufficiently to protect them from wear in passing over the pulleys. This also overcomes the "momentary slippage" reported in some belting tests. Accomplishing this requires sufficient power in the closing of the hooks and the proper diameter of wire.

Three types of rigid connections are also commonly used. These are: Steel lacings (which are in reality a staple which clinches across the end of the belt), hooks, and plates. When steel lacings are applied care must be taken to see that the ends are properly clinched or else they leave a dangerous hook point to catch the clothes of those working around the belt. These are very quickly applied by simply squaring the end of the belt, driving steel points in with a hammer and clinching the ends. They are hard to remove without cutting out a section of belt. This interferes somewhat if only a fraction of an inch of belt is desired to be cut out. If hooks or links are used on belts care must be exercised to see that they are also properly clinched.

Plates are used frequently, especially on conveyor belts, which do not have to pass over idlers, or where the pulley only comes in contact with one surface of the belt. These are commonly riveted on by either solid or split rivets; in some cases bolts are used. The greatest difficulty in connection with these is that for convenience the wrong size is often used. If a plate too small is used the holes are too near the end of the belt. If a plate too large is used, it does not operate satisfactorily over a small pulley. On crowned pulleys, the use of two or more narrow plates is recommended instead of a single wide plate.



Two handy tools for applying metallic flexible lacings to belts.

To lace a belt with rawhide requires considerable time and several devices have been developed for joining belts with some sort of mechanical fastener, so that the work can be done more quickly. The two devices shown make a hinged joint by clinching a loop of wire around each end of the belt. The two ends are then fastened together with a rawhide pin. The upper of these two devices fits in a bench vise and clinches the fastener by screwing up the vise. The other device stands on the bench. These illustrations are by courtesy of the Detroit Belt Lacer Company. Care must be taken to use the right size hook for the belt.

All of these various forms of metal fastenings are becoming quite common largely due to the ease of application. Practically all of them may be used on fabric belts but in any case the proper size should be used as one too small will pull out at the end or not dig far enough into the belt. Each manufacturer makes these in a variety of sizes, each best adapted to a specific type or size of belt. A large percentage of the difficulties incidental to their use is due to using the wrong size, not putting them on straight or not squaring the ends of the belt. Uneven ends throw the strain on a few hooks or rivets and the belts start to tear at this point. Failure to clinch properly has frequently caused injury but this can be prevented by exercising proper care in application.

Some Reasons Why Endless Belts Are Recommended

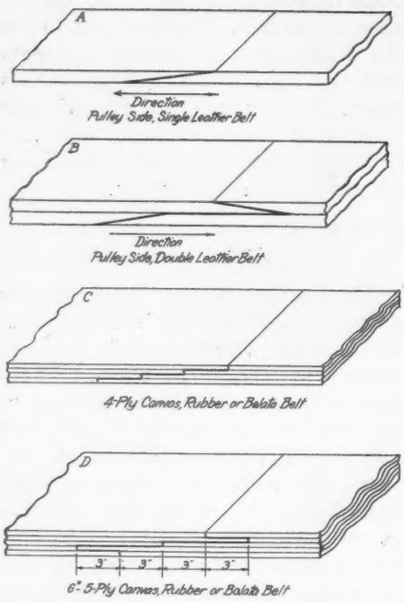
The Leather Belting Exchange, an association of leather belt manufacturers, has recommended that all leather belts be made endless whenever possible. It is probably best to do this in the factory if the belt can be installed endless at the plant. In many cases such as when placed over pulleys on lineshafts this is not convenient. Leather belts can, however, be cemented together at the ends after placing on the pulley. In such cases, as mentioned in the previous article, it is necessary to specify when ordering that it is to be made "with lap" and the exact length given. This, as stated, is best found by measuring with a steel tape. The belt manufacturer will allow for tension and lap. If canvas or fabric belts are to be made endless, that is without any joint, it must be done when the belt is made. However, these belts can be spliced when installed but do not have as smooth a joint as do cemented leather belts. How this joint can be made will be explained later in this article.

Some of the advantages of making belts endless are that they give smooth operation with idlers or over small pulleys, that there are no sharp ends to catch, and that they do not have to be re-laced due to the laces tearing or wearing out. Usually some method must be provided for taking up slack due to a belt stretching after it is in use.

If a leather belt is to be cemented while on the pulleys belt clamps must be used. In any case it is advisable to cement all belts above 4-in. while on the pulleys. Smaller belts are often cemented off the pulleys. After the belt clamps are adjusted and tightened it is well, if the pulleys are far enough apart to permit the belt clamps to move, to rotate the pulleys

Making a 44-in., 3-ply leather belt endless.

This shows how belt clamps are applied when making a leather belt endless. It is recommended that they be used on all belts over 5 or 6 inches in width and they are always necessary when belts are joined while on the pulleys. This large leather belt was supplied by the Chicago Belting Company for a Pacific Coast saw mill.



How joints are made when belts are made endless.

Leather belts can be cemented together at the joints and so made endless in the industrial plant. How the laps are laid out for cementing single and double leather belts is shown in *A* and *B* above. The point of the lap on the outside of the belt should not point in the direction of travel, otherwise the air would soon open the joint. How these joints are made is described in the text. Four- and five-ply canvas rubber or Balata belts may be spliced as shown in *C* and *D*. The first step in joining a fabric-base belt is to cut it down the sides along where the joint is to be made to separate the wrapped plies. The friction coating is next scraped from the top of the belt and the laps warmed with a red-hot iron, care being taken that the iron does not come into actual contact with the belt. The plies are next cut off to the proper length and the surface scraped to roughen the laps. Again warm the belt with a hot iron and apply a rubber belt cement. Many rubber belt cements are inflammable and should be kept away from any fire. After allowing to dry for about twenty minutes, warm the laps again until they become tacky and then stick together and place under a belt press. After putting under moderate pressure for about ten minutes, remove the belt from the press and allow it to cool. Joints should be strengthened by sewing or riveting, or stitching with rawhide. Cemented joints on leather belts when properly made need no reinforcing by rivets or sewing. It is always preferable, if possible, to have belts made endless by the manufacturer. This method of joining fabric base belts is given by R. & J. Dick Company, Inc., in some of their literature.

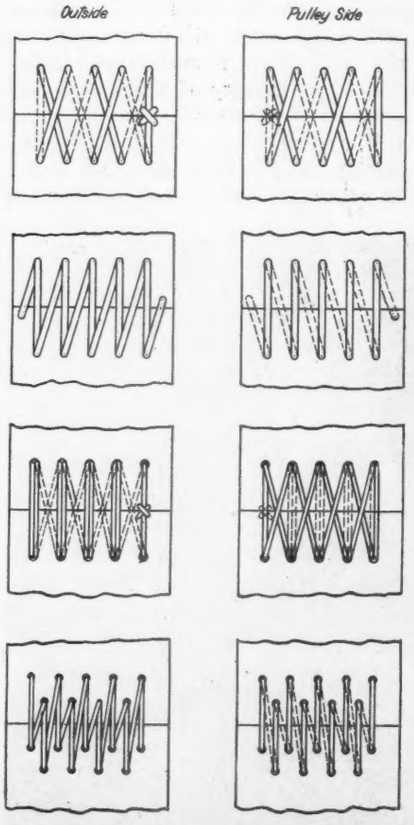
as far as possible in one direction and then back so that the belt clamp goes from one pulley to the next and back again. This permits of more even tension in the belt instead of putting it all in one side.

The Operations in Cementing a Leather Belt

The first step in making a belt endless is to measure the belt and get the proper allowances so as to give the correct tension. Some belt clamps have tension gages which indictate the tension on the belt.

The most common rule in determining the proper tension for a belt is to shorten the belt by ⅛-in. per foot in length below the exact length as indicated by a steel tape line. On cheaper grades of belt a little more, about ¼-in per foot in length, should be taken out. When the length is determined the next step is to make the proper allowance for the lap-joined edge, and then cut the ends square. Ordinarily an allowance of 4-in. for the scarfed or skived edges is made on belts up to 3 in. wide. This increases in steps equal to the increase in width of the belt. Double belts allow 6 in. for lap on belts up to 3 in. wide, 7 in. for 7-in. belts and an allowance equal to the width up to 18 in wide. Above this width only 18 in. are allowed.

The first step is to make the ends square. This is of the utmost importance in any method of joining belts. If the belt man does not have a square or if the belt is wavy, so that a square would not give a true square end, another method is frequently used by practical belt men. This consists of placing the two end pieces of the belt on top of each other with the sides parallel and the ends together, but with one end of one belt twisted so that the smooth side of one comes next to the grain side of the other. If the belt is cut through both thicknesses at the same time, when the ends are turned and put together the two ends will fit together so that the belt is exactly true even though the ends are not perfectly square. It may be well to put together and mark first to be sure that the ends are put together right before cutting. Be sure not to cut off the allowance for lap.



It is best to lay out the lap so that the point of the lap on the grain or outside of the belt does not go against the wind. If a small section at the point of the lap should open up, if the belt goes against the wind, it would soon open the joint and weaken it. A set of belt splicing tools is shown in one of the accompanying illustrations. Practically all belt manufacturers or supply houses keep and supply sets of tools similar to these. After the ends are squared they are skived or scarfed down with a belt plane and finished with a scraper. The surface is then sandpapered lightly to roughen it slightly and any grease spots, which might have gotten onto the surface to be cemented from the hands, are removed with gasoline or naphtha. If a belt is filled with grease or oil it should be cleaned before trying to cement, as oily belts seldom cement well. Methods of degreasing will be explained in the next instalment of this series. The cement should be applied according to the directions given by the manufacturer of the cement. Some of the belt cements are applied hot and others cold. If the belt is to be used in moist or steamy places a waterproof cement should be used.

After the cement is applied to the two edges of the belt by a brush and the ends joined the lap should be laid on a board and hammered lightly, working from the center to the edges to work out any air which may have gotten in the cement and between the two ends of the belt. It should then be put in a press and held under pressure until dry. Small belts are often hammered only. If the ends of a leather belt are cemented properly it *(Continued on page 256)*

Four good methods of lacing belts with rawhide.

One of the most important steps in joining any belt is to see that the ends are cut square. It is also essential that the holes be punched even and in a straight line and not too close to the end of the belt. It is usually best to have the rawhide lacing on the running side in contact with the pulley extend in a straight line lengthwise with the belt. These ways of lacing are recommended in some literature issued by the Chicago Belting Company. Many other ways also make reliable joints.

Practical Details and Tables for

Laying Out Unequal Groupings of Coils

In Induction Motors Having from Four to Forty-Eight Coils Two or Three-Phase

THIS ARTICLE IS the third of a series on connecting induction motors which have equal or unequal coil grouping. Two previous articles have appeared, in the March and April issues of INDUSTRIAL ENGINEER. The present article deals with unequal grouping of coils and treats this subject in a manner somewhat different from that which has been used in the previous articles. It should give the reader a clearer insight into the possibilities of using unequal grouping and a better understanding of balance in a winding.

By A. C. ROE

Repair Superintendent, Detroit Service Department, Westinghouse Electric and Manufacturing Company

THIS DISCUSSION tells of a method of figuring unequal grouping of coils which is different from the methods already described in the March and April issues of INDUSTRIAL ENGINEER. A study of the information presented will give a better understanding of the principles of unequal grouping. The basis of this discussion is an article by E. M. Tingley in the Electrical Review and Western Electrician, Jan. 23, 1915. Mr. Tingley tells how to determine whether a certain number of coils will give a balanced winding, either with equal grouping or unequal grouping. Then he gives tables showing where equal groupings may be used and where unequal groupings must be used. He describes also a method of determining how large and small groups are arranged in an unequal grouping.

In studying Mr. Tingley's discussion it will be noticed that there are two terms which he uses in a somewhat different manner from their usage in the previous discussions in this series. In the first place, he uses the term "number of slots". He states, however, that throughout his article the number of slots equal the number of coils. In the previous discussions the number of slots has not been mentioned. The data have always referred to the number of coils regardless of the number of coils per slot. The second point to remember regarding Mr. Tingley's discussion is that when he refers to a balanced winding he means one

Sixteen-Pole Windings

UNEQUAL COIL GROUPING

TWO-PHASE, TOP-TO-TOP, CHART R

Coils	Group Numbers																				No. Large Groups	No. Small Groups
	1 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32						
48	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1	2 2	1 1					16	16
54	1 2	2 2	1 2–1	2 2	2 1	2 2	1 1	2 2	1 2	2 2	2–1 1	2 2	2 1	2 2	1 1	2 2					22	10
60	1 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	1 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2					28	4
62	2–1 2	2 2	2 2	2 2	2 1	2 2	2 2	2 2	1 2	2 2	2 2	2 2	2 2–1	2 2	2 2	2 2					30	2
72	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2	3 3	2 2	2 2	2 2					8	24
80	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2	3 3	2 2						
84	2 3	3 3	2 2	3 3	3 2	3 3	2 2	3 3	2 3	3 3	2 2	3 3	3 2	3 3	2 2	3 3					20	12
86	2 3	3 3	2 3–1	3 3	3 2	3 3	2 2	3 3	3–1 3	3 3	2 2	3 3	3 2	3 3	2 2	3 3						
90	2 2	3 3	3 3	3 3	3–1 2	3 3	3 3	3 3	2 2	3 3	3 3	3 3	2 3–1	3 3	3 3	3 3					26	6
104	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3	4 4	3 3	3 3	3 3						
108	4 5	5 5	4 4	5 5	5 4	5 5	4 4	5 5	4 5	5 5	4 4	5 5	5 4	5 5	4 4	5 5						
120	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4	3 3	4 4	4 4	4 4					24	8
135	5 4	4 4	5–1 4	4 4	4 5	4 4	4 5–1	4 4	5 4	4 4	4 5–1	4 4	4 5	4 4	4 4	4 4					7	25
144	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4	5 5	4 4						
150	4 5	5 5	4 5–1	5 5	5 4	5 5	4 4	5 5	4 5	5 5	5–1 4	5 5	5 4	5 5	4 4	5 5					22	10
156	4 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5	4 5	5 5	5 5	5 5	5 4	5 5	5 5	5 5						
168	6 6	5 5	5 5	5 5	6 6	5 5	5 5	5 5	6 6	5 5	5 5	5 5	6 6	5 5	5 5	5 5						
180	5 6	6 6	5 5	6 6	6 5	6 6	5 5	6 6	5 6	6 6	5 5	6 6	6 5	6 6	5 5	6 6						
216	6 6	7 7	7 7	7 7	6 6	7 7	7 7	7 7	6 6	7 7	7 7	7 7	6 6	7 7	7 7	7 7						
240	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8	7 7	8 8						

absolutely in balance from the theoretical standpoint. There are many possible windings which are not absolutely balanced, but which give, however, practically perfect operating characteristics. These latter windings have been included in the previous discussions. The number of possible connections with certain numbers of coils is greatly increased if these latter windings are used. Mr. Tingley's article follows:

Two-Phase and Three-Phase Lap Windings in Unequal Groups

"The following method of grouping lap windings in unequal groups per phase per pole, for induction motors, alternating-current generators, and similar apparatus, has the advantage of largely increasing the number of combinations of slots, poles and phases that may be used, over those obtainable with equal

Table I — Balanced Two-Phase and Three-Phase Windings

Any number of slots which is a multiple of the number opposite the number of poles will give balanced windings.*

Poles.	Three-phase.	Two-phase.
2	3	4
4	3	8
6	9	4
8	3	16
10	3	4
12	9	8
14	3	4
16	3	32
18	27	4
20	3	8
22	3	4
24	9	16
26	3	4
28	3	8
30	9	4
32	3	64
34	3	4
36	27	8
38	3	4
40	3	16
42	9	4
44	3	8
46	3	4
48	9	32
50	3	4
52	3	8
54	81	4
56	3	16
58	3	4
60	9	8
62	3	4
64	3	128
66	9	4
68	3	8
70	3	4
72	27	16
74	3	4
76	3	8
78	9	4
80	3	32
82	3	4
84	9	8
86	3	4
88	3	16
90	27	4
92	3	8
94	3	4
96	9	64
98	3	4
100	3	8
102	9	4
104	3	16
106	3	4
108	81	8
110	3	4
112	3	32
114	9	4
116	3	8
118	3	4
120	9	16
122	3	4
124	3	8
126	27	4
128	3	256
130	3	4
132	9	8
134	3	4
136	3	16
138	9	4
140	3	8

*There are other numbers of slots, as shown in Tables IV and V and in the Main Table and the grouping charts accompanying this series, which may be used to give unequal groups satisfactory in practice though not absolutely balanced.

Sixteen-Pole Windings

UNEQUAL COIL GROUPING

THREE-PHASE, TOP-TO-TOP, CHART Y

Coils	Group Numbers 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	No. Large Groups	No. Small Groups
54	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	6	42
60	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	2	1	1	1	2	1	1	1	1	2	1	2	2	2	2	2	2	12	36
62	2	1	2–1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	1	1	2	1	2–1	1	2	1	1	2	1	1	1	2	1	1	1	1	2	1	2	2	2	2	2	2	14	34
72	2	1	2	1	2	1	1	1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2	2	2	2	2	24	24
80	1	2	2	2	1	2	2	2	1	2	1	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	–1	2	2	2	2	2	1	2	2	2	2	2	2	2	16	16
84	1	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	2	32	12
86	1	2	2	2	2–1	2	2	2	2	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	1	2	2	2	2–1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	38	10
90	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	42	6
104	3	2	2	2	3–1	2	2	2	3	2	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	2	2	8	40
108	3	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	2	2		
120	3	2	3	2	2	2	2	3	2	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	2	2		
128	2	3	2	2	2	2	3	2	2	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	2	2	2	2		
135	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	9	
150	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	3	3	3	3		
156	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	3	3	3	3		
160	4	3	3	3	4	3	3	3	4	3	4	3	3	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	4	3	4	3	3	3	4	3	3	3	3	3	3	3	16	32
168	4	3	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4	3	4		
180	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
216	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4		

groups per phase per pole. While it may not be new, it is not generally known or used. The form in which it is herewith presented may be new. Several designing engineers have used such windings in special cases, but apparently without investigating all the possible combinations.

"The continuous or two-circuit retrogressive and progressive windings in which the number of slots is one more or less than a multiple of the number of pairs of poles are now seldom used, either as closed or continuous windings or as open windings, for the stators of induction motors or alternating-current generators. Such windings were used a few years ago in rotating-armature generators and they are now used

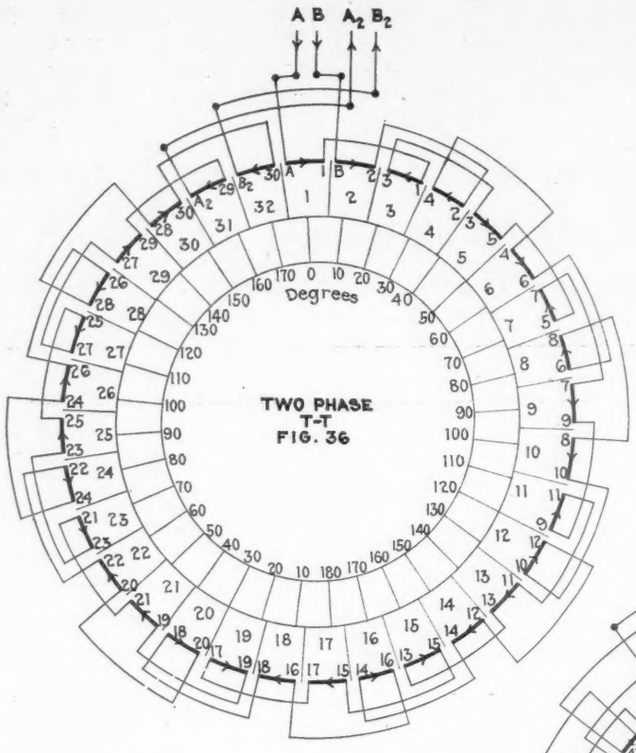
Table II—Possible Three-Phase Windings with Various Numbers of Slots

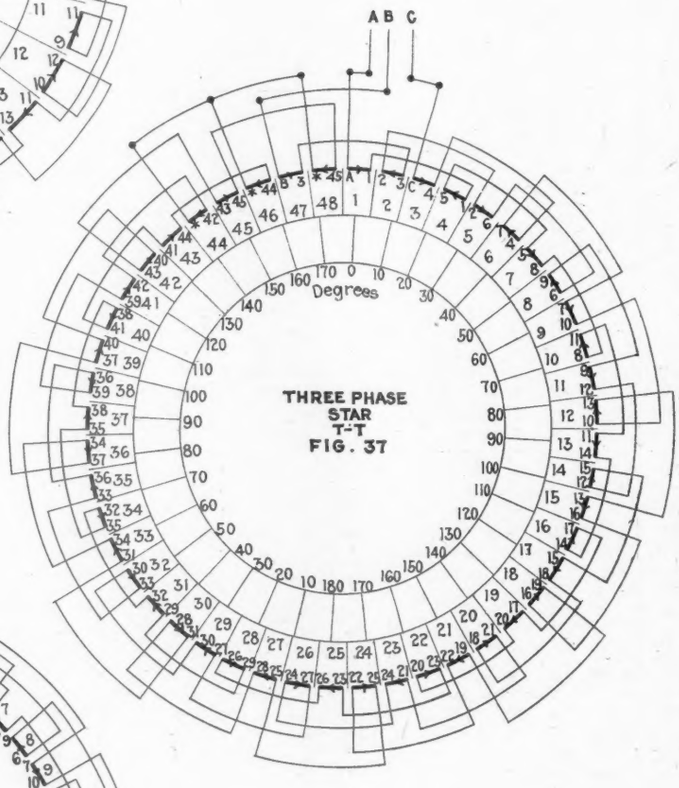
No. Coils	Number of Poles																							
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
12†	=	=																						
15	★	0																						
18	=	★	=																					
21	★	0	•																					
24†	=	=	•	=																				
27	★	0	★	0																				
30	=	★	•	★	=																			
33	★	0	•	0	★																			
36†	=	=	=	★	0	=																		
39	★	0	•	0	0	•																		
42	=	★	•	★	★	•	=																	
45	★	0	★	0	★	★	★																	
48†	=	=	•	=	★	•	0	=																
51	★	0	•	0	0	•	★	★																
54	=	★	=	★	0	★	★	★	=															
57	★	0	•	0	★	•	0	0	•															
60†	=	=	•	★	=	•	★	★	•	=														
63	★	0	★	0	★	★	★	0	•	★														
66	=	★	•	★	0	•	★	★	•	★	=													
69	★	0	•	0	0	•	0	★	•	0	★													
72†	=	=	=	=	★	=	★	★	•	★	★	=												
75	★	0	•	0	★	•	★	★	•	★	★	•												
78	=	★	•	★	★	•	0	★	•	★	0	•	=											
81	★	0	★	0	0	★	★	0	★	0	★	★	★											
84†	=	=	•	★	0	•	=	★	•	★	★	•	★	=										
87	★	0	•	0	★	•	★	0	•	★	0	•	★	★										
90	=	★	=	★	=	★	0	★	•	★	★	★	0	★	=									
93	★	0	•	0	★	•	★	★	•	★	★	•	★	★	•									
96†	=	=	•	=	0	•	★	=	•	★	★	•	★	★	•	=								
99	★	0	★	0	0	★	0	★	•	0	★	★	★	0	★	★								
102	=	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	=							
105	★	0	•	0	★	•	★	0	•	★	★	•	0	★	•	★	★							
108†	=	=	=	★	★	=	★	★	=	★	★	★	★	★	★	★	★	=						
111	★	0	•	0	0	•	0	0	•	0	0	•	★	0	•	0	★	•						
114	=	★	•	★	0	•	★	★	•	★	★	•	★	★	•	★	★	•	=					
117	★	0	★	0	★	★	★	★	•	★	★	★	★	★	★	★	★	•	★					
120†	=	=	•	=	=	•	0	★	•	=	0	•	★	★	•	★	0	•	★	=				
123	★	0	•	0	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★				
126	=	★	=	★	0	★	=	★	•	★	★	★	★	★	★	★	★	•	★	★	=			
129	★	0	•	0	0	•	★	0	•	0	★	•	0	★	•	0	★	•	★	★	•			
132†	=	=	•	★	★	•	0	★	•	★	=	•	★	★	•	★	★	•	0	★	•	=		
135	★	0	★	0	★	★	★	0	★	★	★	★	★	★	★	★	0	★	★	★	★	★		
138	=	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	=	
141	★	0	•	0	0	•	0	★	•	0	★	•	★	0	•	★	★	•	★	0	•	★	★	
144†	=	=	=	=	0	=	★	=	•	★	0	=	0	★	★	★	★	•	★	★	★	★	★	=
147	★	0	•	0	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•
150	=	★	•	★	=	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•	★	★	•

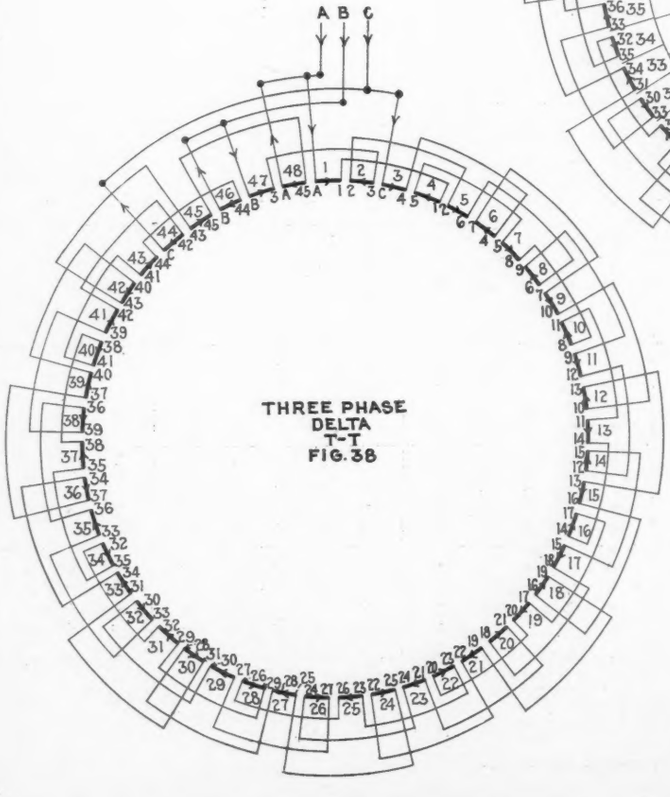
† Slots suitable for two phases also.
= Equal group windings.
★ Unequal group windings.
0 Unequal group windings for lap or two-circuit wave winding.
• Not perfectly balanced but satisfactory in practice for unequall y grouped lap windings.

Sixteen-Pole Windings

See Tables on page 246 and 247 Showing the Corresponding Groupings and Method of Connecting Ends of Groups.







frequently in wound induction-motor rotors, partly on account of the wave form of end connectors and also for obtaining desired ratios between stator and rotor slots. To obtain balanced or symmetrical phases as regards current and voltage the number of coils per phase must be equal. Possibly such windings have not been used more frequently because it has been thought that the required number of slots for a particular case would answer only for that case, and also because acceptable combinations of slots and poles are very limited in number. With such windings in open connection it is immaterial whether the end connections are of the wave or of the lap form. In general the form of end connections that gives the

Table III—Possible Two-Phase Windings with Various Numbers of Slots

No. Coils	Number of Poles																						
	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	33	40	42	44	46	48
4	=																							
8	=	=																						
12†	=	•	=																					
16	=	=	0	=																				
20	=	•	0	•	=																			
24†	=	=	=	•	0	=																		
28	=	•	0	•	★	•	=																	
32	=	=	0	=	★	★	★	=																
36†	=	•	=	•	0	•	0	•	=															
40	=	=	0	•	=	★	★	•	★	=														
44	=	•	0	•	0	•	★	•	0	•	=													
48†	=	=	=	=	★	=	0	•	★	★	★	=												
52	=	•	0	•	★	•	★	•	★	•	★	•	=											
56	=	=	0	•	0	★	=	•	★	★	0	•	★	=										
60†	=	•	=	•	=	•	★	•	★	•	★	•	★	•	=									
64	=	=	0	=	0	★	0	=	0	★	★	★	0	★	★	=								
68	=	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•	=							
72†	=	=	=	•	★	=	★	•	=	★	★	•	★	★	★	•	★	=						
76	=	•	0	•	0	•	0	•	★	•	0	•	★	•	0	•	★	•	=					
80	=	=	0	=	=	★	★	•	0	=	★	★	★	★	★	•	★	★	★	=				
84†	=	•	=	•	0	•	=	•	★	•	★	•	★	•	★	•	0	•	★	•	=			
88	=	=	0	•	★	★	★	•	★	★	=	•	★	★	★	•	★	★	★	•	★	=		
92	=	•	0	•	★	•	0	•	★	•	★	•	0	•	★	•	★	•	★	•	★	•	=	
96†	=	=	=	=	0	=	★	=	★	★	★	=	★	★	★	•	★	★	0	★	★	★	★	=
100	=	•	0	•	=	•	★	•	0	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•
104	=	=	0	•	0	★	0	•	★	★	★	•	=	★	0	•	★	★	★	•	0	★	★	•
108†	=	•	=	•	★	•	★	•	=	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•
112	=	=	0	=	★	★	=	•	★	★	★	★	★	=	★	•	★	★	★	★	★	★	★	•
116	=	•	0	•	0	•	★	•	0	•	★	•	0	•	★	•	★	•	★	•	★	•	0	•
120†	=	=	=	•	=	=	0	•	★	=	0	•	★	★	=	•	0	★	★	•	★	★	★	•
124	=	•	0	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•
128	=	=	0	=	★	★	★	=	★	★	★	★	★	★	★	=	★	★	★	★	★	★	★	★
132†	=	•	=	•	★	•	0	•	★	•	=	•	★	•	★	•	★	•	0	•	★	•	★	•
136	=	=	0	•	0	★	★	•	0	★	★	•	★	★	0	•	=	★	★	•	★	★	★	•
140	=	•	0	•	=	•	=	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•	★	•
144†	=	=	=	=	0	=	★	•	=	★	0	=	0	★	★	•	★	=	★	★	★	★	★	•
148	=	•	0	•	★	•	0	•	★	•	★	•	★	•	★	•	★	•	★	•	0	•	★	•
152	=	=	0	•	★	★	★	•	0	★	★	•	★	★	★	•	0	★	=	•	★	★	★	•
156†	=	•	=	•	0	•	★	•	★	•	★	•	=	•	★	•	★	•	★	•	★	•	★	•
160	=	=	0	=	=	★	0	=	★	=	★	★	★	★	★	•	★	★	★	=	★	★	0	★
164	=	•	0	•	0	•	★	•	★	•	0	•	★	•	0	•	★	•	★	•	★	•	★	•
168†	=	=	=	•	★	=	=	•	★	★	★	•	0	=	★	•	★	★	★	•	=	★	★	•
172	=	•	0	•	★	•	★	•	0	•	★	•	★	•	★	•	★	•	0	•	★	•	★	•
176	=	=	0	=	0	★	0	•	★	★	=	★	★	★	★	•	★	★	★	★	★	=	★	•
180†	=	•	=	•	=	•	★	•	=	•	★	•	★	•	=	•	★	•	★	•	★	•	★	•
184	=	=	0	•	0	★	★	•	★	★	★	•	★	★	★	•	★	★	★	•	★	★	=	•
188	=	•	0	•	★	•	0	•	0	•	0	•	★	•	★	•	0	•	★	•	0	•	★	•
192†	=	=	=	=	★	=	★	=	★	★	★	=	★	★	★	=	★	★	★	★	★	★	★	=
196	=	•	0	•	0	•	=	•	★	•	★	•	0	•	0	•	★	•	★	•	★	•	★	•
200	=	=	0	•	=	★	★	•	★	=	★	•	★	★	★	•	★	★	★	•	★	★	★	•
204†	=	•	=	•	0	•	0	•	★	•	★	•	★	•	★	•	=	•	★	•	★	•	★	•

† Slots suitable for three phases also.
= Equal group windings.
★ Unequal group windings.
0 Unequal group windings for lap or two-circuit wave winding.
• Not perfectly balanced but satisfactory in practice for unequally grouped lap windings.

Sixteen-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two Phase, Top-to-Top. See Fig. 36

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13
2 Parallel															A_2
4 Parallel							A_2	B_2	A	B					
8 Parallel			A_2	B_2	A	B					A_2	B_2	A	B	
16 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A

Three-Phase Star, Top-to-Top. See Fig. 37

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24
2 Parallel																				*		*	B
4 Parallel								*		*	B	*	A		C								
8 Parallel		*		*	B	*	A		C		*		*			*	B	*	A		C		
16 Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*

Three-Phase Delta, Top-to-Top, See Fig 38

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24
2 Parallel																				C		B	B
4 Parallel								C		B	B	A	A		C								
8 Parallel		C		B	B	A	A		C		B	B	A	C		B	B	A	A		C		
16 Parallel	B	B	A	A	B	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	C

Eighteen-Pole Induc-

CONNECTIONS FOR ENDS OF GROUPS

Two-Phase, Top-to-Top. See Fig. 39

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Series	A 1	B 2	3 1	4 2	3 5	4 6	7 5	8 6	7 9	8 10	11 9	12 10	11 13	12 14	15 13	16 14	15 17
2 Parallel																	A_2
3 Parallel											A_2	B_2	A	B			17
6 Parallel					A_2	B_2	A	B									A_2
9 Parallel			A_2	B_2	A 5	B 6	A_2 5	B_2 6	A	B					A_2	B_2	A 17
18 Parallel	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2	B_2	A	B	A_2

Three-Phase Star, Top-to-Top. See Fig. 40

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24
2 Parallel																							*		*	B
3 Parallel														*		*	B	*	A		C		24		26	24
6 Parallel					*		*	B	*	A			C										*		*	B
9 Parallel		*		*	B 6	*	A 8	* 6	C 10	* 8	B	*	10 A		C				*		*		B 24	*	A 26	* 24
18 Parallel	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B	*	A	*	C	*	B

Three-Phase Delta, Top-to-Top. See Fig. 41

Group No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Series	A 1	2 3	C 4	5 1	2 6	7 4	5 8	9 6	7 10	11 8	9 12	13 10	11 14	15 12	13 16	17 14	15 18	19 16	17 20	21 18	19 22	23 20	21 24	25 22	23 26	27 24
2 Parallel														C		B	B	A	A		C		C		B	B
3 Parallel																							24		26	24
6 Parallel					C		B	B	A	A		C											C		B	B
9 Parallel		C		B	B 6	A	A 8	C 6	C 10	B 8	B	A 10	A		C				C		B	B	B 24	A	A 26	C 24
18 Parallel	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B	A	A	C	C	B	B

tion Motor Windings

——Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Two-Phase (Continued)

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
16 14 B₂	15 17 A	16 18 B	19 17 A₂	20 18 B₂	19 21 A	20 22 B	23 21 A₂	24 22 B₂	23 25 A	24 26 B	27 25 A₂	28 26 B₂	27 29 A	28 30 B	A₂ 29 A	B₂ 30 B
B	A₂	B₂	A	B	A₂	B₂	A	B	A₂	B₂	A	B	A₂	B₂	A	B

Three-Phase Star (Continued)

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
25 22 * C	23 26 A *	27 24 * B	25 28 C *	29 26 * A	27 30 B *	31 28 * C	29 32 A *	33 30 * B	31 34 C *	35 32 * A	33 36 B *	37 34 * C	35 38 A *	39 36 * B	37 40 C *	41 38 * A	39 42 B *	43 40 * C	41 44 A *	* 42 B *	43 45 C *	* 44 A *	B 3 * C	* 45

Three-Phase Delta (Continued)

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
25 22 A C	23 26 A B	27 24 C B	25 28 C A	29 26 B A	27 30 B C	31 28 A C	29 32 A B	33 30 C B	31 34 C A	35 32 B A	33 36 B C	37 34 A C	35 38 A B	39 36 C B	37 40 C A	41 38 B A	39 42 B C	43 40 A C	41 44 A B	C 42 B B	43 45 C A	B 44 A A	B 3 C C	A 45

tion Motor Windings

——Connect together group ends having same number or letter. Letters indicate line leads. A star connection is shown by (*).

Two-Phase (Continued)

18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
16 18 B₂ 18	19 17 A 17	20 18 B 18	19 21	20 22	23 21 A₂	24 22 B₂	23 25 A	24 26 B	27 25	28 26	27 29 A₂	28 30 B₂	31 29 A	32 30 B	31 33	32 34	A₂ 33	B₂ 34
B₂ B 18 A₂ B₂	A 17 B₂ A	B 18 A B	A₂	B B₂	A	B	A₂	B₂	A	B₂	A 29 B A₂	B 30 A₂ B₂	A 29 B₂ A	B 30 A B	A₂	B B₂	A	B

Three-Phase Star (Continued)

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25 28 * 28	29 26 A 26	27 30	31 28 C 28	29 32	33 30 *	31 34	35 32 *	33 36 B	37 34 *	35 38 A	39 36	37 40 C	41 38	39 42 B	43 40	41 44 A	45 42 B	43 46 C	47 44 A	45 48 B	49 46 C	47 50 A	* 48	49 51 C	* 50	B 3 A	* 51
C 28 *	* 26 A	B *	* 28 C	A *	B	C *	A	*	C	*	* B	*	A	B 42 *	* C	A 44 *	* 42 B	C 46 *	* 44 A	B *	* 46 C	A	B	C *	A	*	C

Three-Phase Delta (Continued)

27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25 28 A 28	29 26 A 26	27 30	31 28 C 28	29 32	33 30 C	31 34	35 32 B	33 36 B	37 34 A	35 38 A	39 36	37 40 C	41 38	39 42	43 40	41 44	45 42	43 46	47 44	45 48	49 46	47 50 A	C 48	49 51 C	B 50	B 3 A	A 51
A C 28 B A	A 26 B A	C	A 28 C	A B	B	C A	A	C	C	B	C B	A	B	C 42 C	A C	A 44 B	C 42 B	C 46 A	B 44 A	B C	A 46 C	A B	B	C A	A	C	C

best mechanical construction should be used. *We shall here assume that the number of coils is equal to the number of slots.*

"The point to be made, however, is that these unequally grouped windings will give an electrical performance similar to the equally grouped windings almost universally used.

"Now there is also a large number of other similar combinations of slots, poles and phases, having an unequal number of slots per phase per pole or a fractional number of slots per phase per pole, as have the two-circuit windings, that will give symmetrical or balanced lap windings in the open-circuit connections, but which may not be conveniently two-circuit connected with the wave-form end connectors, and will require the lap form of end connectors.

"The method of analysis for obtaining these group combinations for three phases and for two phases is as follows: "A little study with a simple circular diagram of poles and slots will show that three equally spaced slots will give three balanced phases, as regards voltage, with any number of pairs of poles not a multiple of three. The same is also true of any number of equally spaced slots which is a multiple of three. Therefore, any multiple of three slots will give three balanced phases with any number of pairs of poles not a multiple of three."

Three slots containing three coils will give two poles provided they are connected to give what is known as "consecutive poles." Ordinarily such a connection is not employed. Six coils (or six groups) are usually employed to give two poles. However, this fact does not affect the reasoning so far as balanced voltage is concerned.

"The minimum number of slots for three phases with any other number of poles is determined from the factors of that number of poles. Six poles may be considered as three two-pole machines in one and inasmuch as three slots is the minimum number for two poles, then nine slots or any multiple of nine slots will give balanced phases with six poles. Thirty poles is the same as three ten-pole machines in one; therefore any multiple of nine slots will give three balanced phases with thirty poles."

As already stated when introducing Mr. Tingley's article the reasoning in the preceding paragraph holds only for absolutely balanced windings. In practice the limiting conditions are not so narrow. In fact, any number of coils divisible by 3 will form a balanced series three-phase winding. It will be balanced so far as the number of coils in series per phase is concerned. It may not be possible with certain numbers of poles and coils to distribute the large groups in a perfectly even or symmetrical manner around the winding. However, if they are distributed in a fairly even arrangement the winding will operate satisfactorily. Mr. Tingley does not include such a winding under his

Eighteen-Pole Two-Phase Windings

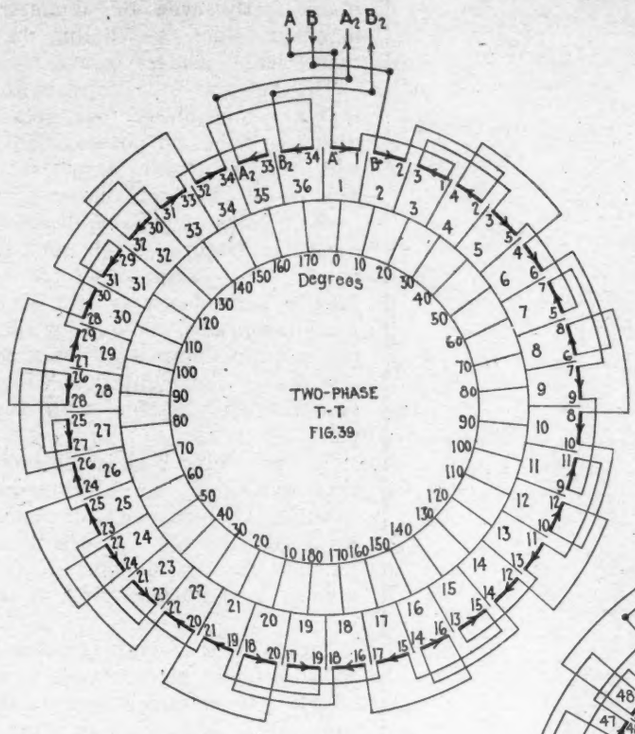
UNEQUAL COIL GROUPING — TWO-PHASE, TOP-TO-TOP, CHART S

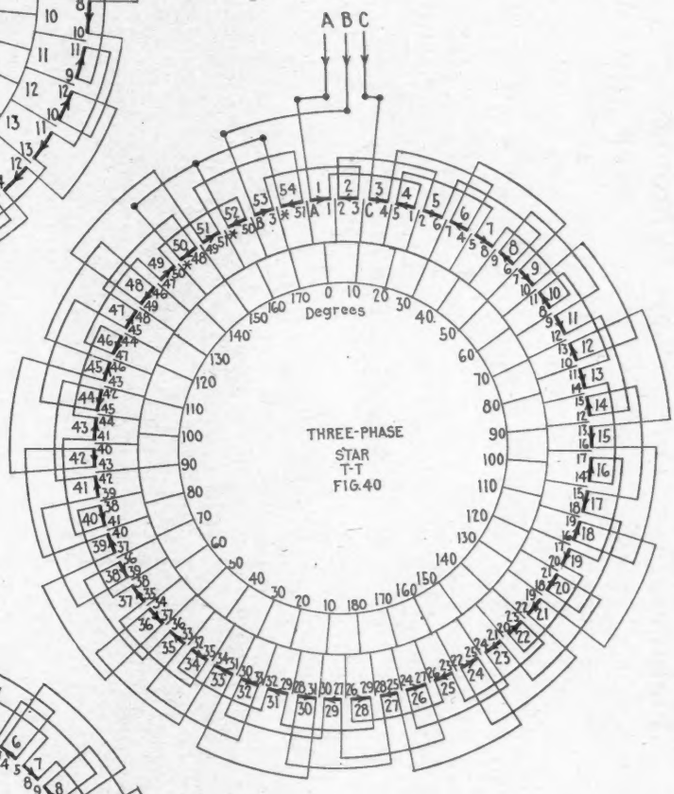
Groups	Group Numbers																								No. Large Groups	No. Small Groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
48	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	2	1	1	12	24
54	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	2	2	1	1	18	18
60	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	24	12
62	1	2	2	1	2	2	2–1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	2–1	2	2	2	1	2	2	1	2	26	10
80	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	8	28
84	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	14	22
86	3	2	2	3	2	3–1	3	2	2	3	2	2	3	2	2	3	2	2	3	2	2	3	2	3–1	3	2	2	3	2	2	3	2	2	3	2	2	34	2
90	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	3	3	2	2	20	16
96	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3	2	3	3		
104	2	3[k]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3[k]	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	27	9
120	4	3	3	4	3	3	4	3	3	4	3	3	4	3	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	30
128	3	3	4	4	4	4	3	3	3	3	4	4	3	3	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		
135	3	4[k]	4	4	4	4	4	4	3	3	3	4–1	4	4	4	4	4	4	4	3[k]	4	4	4	4	4	4	4	4	4	4	4	4	5	5	4	5	5	16	20
150	5[k]	4	4	4	4	4	4	5	4	4	4	4	5	4	4	4	4	4	4	5[k]	4	4	4	4	5	4	4	4	5	4	4	4	5	4	4	4		
156	5	4	4	5	4	4	5	4	5	4	4	4	5	4	5	4	4	4	4	4	5	4	4	4	5	4	5	4	5	4	5	4	5	4	5	4		
160	5	5	4	4	4	4	5	5	5	5	4	4	5	5	4	4	4	4	5	5	4	4	4	4	5	5	5	5	4	4	5	5	4	4	4	4	16	
168	4	5	5	4	5	5	4	5	5	4	5	5	4	5	4	5	5	5	4	5	5	4	5	5	4	5	4	5	5	5	4	5	5	5	5	5		
240	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7	6	7	7		

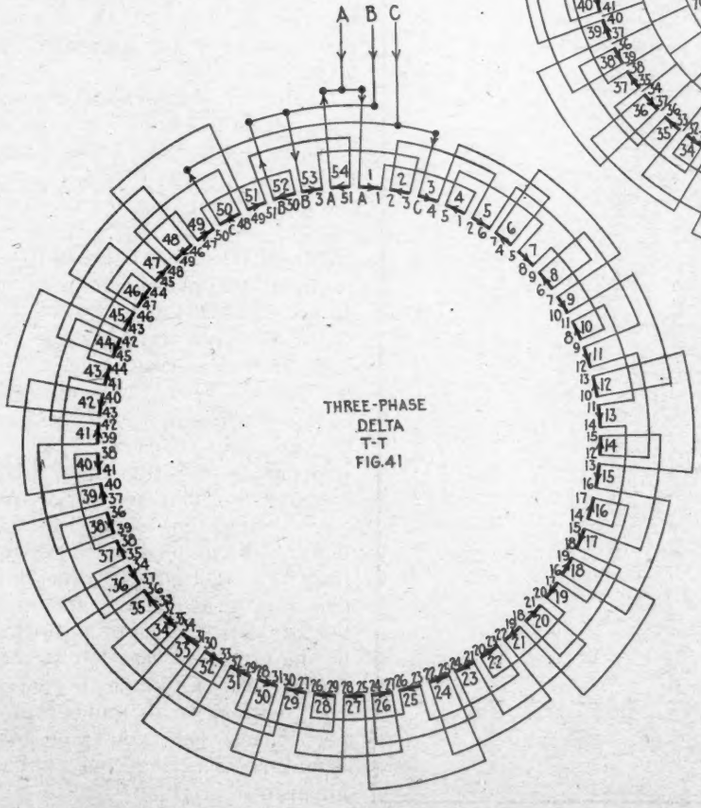
[k]A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

Eighteen-Pole Windings

See Tables for Connecting Ends of Groups that appear on pages 246 and 247.







Eighteen-Pole Three-Phase Windings

UNEQUAL COIL GROUPING — THREE-PHASE, TOP-TO-TOP, CHART Z

Coils	Group Numbers																																					No. Large Groups	No. Small Groups
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54		
60	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6	48
62	2	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	2	1	1	1	1	1	2–1	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2–1	1	1	1	8	46
72	2	1	2	1	2	1	1	1	1	2	1	1	1	2	1	1	1	1	2	1	2	1	2	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	36
80	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	1	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2–1	1	2	1	2	1	2	1	2	1	2	1	2	1	2–1	1	2	1	2	1	2	26	28
84	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2k	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2k	1	2	1	2	1	2	1	2	1	2	1	2	1	2k	1	2	1	2	1	2	1	30	24
86	2–1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	2k	2	1	2	2–1	2	1	2	1	2	1	2	1	2	1	2	2k	1	2	1	2	1	2	1	2	1	2	1	2	1	2k	1	2	1	2	1	2	1	32	22
90	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	2	2	2	1	2	1	2	1	2	1	2	2	1	2	1	2	1	2	2	2	2	1	2	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2	2	36	18
96	1	2	2	2	1	2	2	2	1	2	2	1	1	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	1	2	2	1	2	2	2	1	2	2	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	42	12
104	1	2	2	2	2	2	2	2	2–1	2	2	2	1	2	2	2	1	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	50	4
120	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	3	2	2	2	2	2	3	2	2	2	2	3	2	2	2	3	2	2	2	2	2	3	2	2	2	2	2	3	2	2	2	2	2	3	12	42
128	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	2	2	3	2	3	2	3	2	2	3	2–1	2	3	2	2	3	2	2	2	2	3	2	2	3	2	2	3	2	2	2	2	2	3	2	2	2	2	2	20	34
135	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	2	3	2	3	2	3	2	3	2	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	27	27
144	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	3	3	3	2	3	2	3	2	3	3	3	3	3	2	3	3	2	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	36	18
150	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	3	3	3	2	3	3	3	3	3	2	3	3	3	48	6
156	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		
160	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3–1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	52	2
168	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	3	4	3	3	3	3	3	3	3	4	3	3	3	3	3	4	3	3	3		
180	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	4	3	4	3	4	3	3	3	3	3	4	3	4	3	3	3	4	3	3	3	4	3	3	3	4	3	3	24	30
240	5	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	4	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	4	5	4	5	4	5	4	5	4	5	4	5	4	5	4	4	4	5	4	5	4	5		

[k] A coil is killed in each group where this symbol appears provided it appears also in the Main Table for this winding.

term "balanced windings." He includes only those windings in which the larger groups may be distributed in perfectly even or symmetrical manner. Such a winding has a theoretically perfect balance.

"In the same way it will be found that any multiple of four slots will give two balanced phases with any odd number of pairs of poles. The number of slots for the even numbers of pairs of poles is determined from the factors of the number of poles. For example, twelve poles may be considered as two six-pole machines in one, and as four slots is the minimum number for six poles, any multiple of eight slots will give two balanced phases with twelve poles."

The reasoning here is the same as that explained for a three-phase winding. It holds only for perfectly balanced windings. In practice any number of coils divisible by 2 will give a satisfactory two-phase series winding.

"Some of the above combinations will of course give a whole number of slots per phase per pole, or equally grouped windings. For quick inspection of all the possible combinations of slots and poles the accompanying tables for three phases and for two phases have been prepared. Such tables may be extended indefinitely as regards slots or poles.

"Table No. I gives the minimum number of slots for three and for two phases for any number of poles up to 140.

"Table II shows all the possible three-phase balanced windings up to 48 poles and 150 slots. The character under the number of poles indicates the type of winding for the number of slots opposite.

"Table III gives the same data for balanced two-phase windings up to 48 poles and 204 slots.

"In all these windings the phases have, in a given case, equal numbers of coils. Where the number of coils per phase per pole is not equal, the average position of the coils compensates for this inequality and balances the phases electrically. Of course there is a practical lower limit to the number of slots per pole that may be used; say, one slot per phase per pole. The larger the number of slots the more uniform will be the armature reaction at the different poles, although in generators built with a small number of slots per phase per pole non-uniform armature reaction has not been apparent.

Lighting units consisting of 200-watt clear Mazda C lamps in combination glass-and-steel reflectors give an average illumination of twelve foot-candles in this lamp factory. These units are spaced 10 ft. by 10 ft. 8 in. and are mounted 11 ft. above the floor.

Practical Advantages of

Flexibility in a Lighting System

By the Proper Placing of Outlets and Adequate Wiring and Switching

By JAMES M. KETCH and A. F. IRISH

Engineering Department, National Lamp Works of General Electric Company, Cleveland, Ohio

IT REQUIRES little more than a casual observation in the average industrial plant to see the need for a flexible lighting system. Flexibility as it is applied here, means that the lighting system should adequately meet not only the normal variations in the day's work but should also be able to care for possible changes in machine arrangement, kind of work carried on and the like, over a period of years. Based on the writers' own experience, it appears that too often the various operations in an industrial works are each classed as a special lighting problem, whereas in many cases one of the standard methods of lighting could be profitably applied. There is no question but that special applications of lighting to machines have brought forth some excellent examples of mechanical ingenuity but in such cases maximum flexibility is usually not obtained.

It should not be inferred from what has been said that there is any one set of rules which will give the answer to all shop lighting problems or which will give perfect flexibility in the lighting system. There are, however, a number of standard methods of lighting which if properly applied will undoubtedly afford the greatest practical flexibility in most cases. In fact, one of the best reasons for the popularity of general overhead systems of a fairly high foot-candle value, is their adaptability to a wide variation in working conditions.

Fundamentally there are five factors which contribute to the flexibility of a lighting system:

(1) The proper spacing of outlets so that regardless of the lamp wattage a uniform level of illumination may be obtained over the entire working area.

(2) An illumination of sufficiently high foot-candle value over the entire area sufficient to care for the most exacting work to be carried on.

Five Factors that Contribute Toward Flexibility of a Lighting System

1—The proper spacing of outlets so that regardless of the lamp wattage a uniform level of illumination may be obtained over the entire working area.

2—An illumination of sufficiently high foot-candle value over the entire area sufficient to care for the most exacting work to be carried on.

3—Sufficient copper to permit more light or wattage to be obtained when needed.

4—A switching arrangement that will economically provide light at the desired time and place.

5—The selection of a reflector that will allow for a future change in lamp size and wattage.

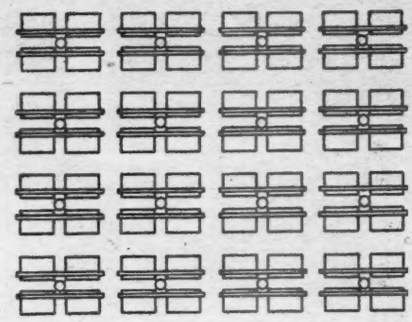


Fig. 1—One lighting unit is used in the center of each group of four looms. With looms removed, a good general overhead system remains.

(3) Sufficient copper to permit more light or wattage to be obtained when needed.

(4) A switching arrangement that will economically provide light at the desired time and place.

(5) The selection of a reflector that will allow for a possible future change in lamp size and wattage.

Light Distribution for Flexibility of Operations

General Lighting—As already suggested, general overhead lighting with the proper spacing of outlets permits of freedom in the arrangement of machines and processes. It was during the rush of war activities, when all industrial plants were adapting themselves to the new and larger demands suddenly placed upon them, that the value and flexibility of general lighting became more widely appreciated. Where workmen are obliged to move about from one machine to another or to bench or assembly work, the ordinary losses of time are undoubtedly reduced to a minimum under high-intensity, general lighting systems.

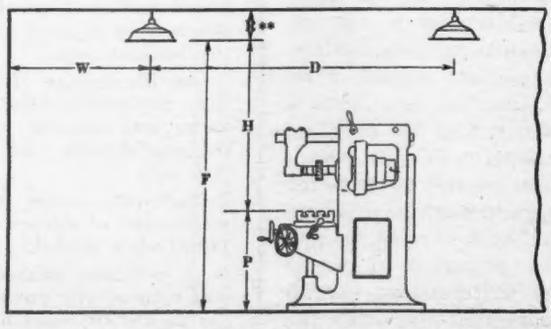
If the room under consideration can be successfully lighted by natural daylight, it is usually considered practicable to adequately light the work space by a well-designed general lighting system. A distinct advantage of artificial lighting is that the illumination can be made uniform throughout the entire work area. In this respect it is possible to simulate outdoor daylight conditions.

Since the success of a general lighting system depends upon the units being properly spaced and mounted, it will not be out of place here to suggest spacing and mounting ratios ordinarily employed for direct-lighting units. The spacing ratios in Table I can be worked either way; that is, the spacing of the outlets may be determined by the bay sizes or machine arrangement, in which case the units themselves should be hung not lower than the minimum height shown in Table I. In other cases the mounting height is limited by the height of the ceiling, in which case the maximum spacing as shown in Table I may be followed.

In column 5 of Table I is given the maximum allowable distance between the walls and the first row of units which applies in cases where there are work benches, machines or desks next to the wall. It is suggested that this spacing be used if there seems to be any possibility at all later, of work being carried on next to the wall. In locations where aisles or storage spaces are next to the wall, column 4 is used. Where the spacing and mounting height values given in this table are followed a fairly even illumination will be obtained which allows consider-

TABLE I—Spacing Distances and Mounting Heights for Direct Lighting Units

Mounting Height of Unit		Permissible Distance Between Outlets	Permissible Distance Between Outlets and Sidewalls	
Above Plane of Work (H)	Above Floor* (F)	(D)	In Usual Locations Where Aisles & Storage Are Next to Wall (W)	Where Work Benches are Next to Wall (W)
4	6½	6	3	2
5	7½	7½	3½	2½
6	8½	9	4½	3
7	9½	10½	5	3½
8	10½	12	6	4
9	11½	13½	6½	4½
10	12½	15	7½	5
11	13½	16½	8	5½
12	14½	18	9	6
13	15½	19½	9½	6½
14	16½	21	10½	7
15	17½	22½	11	7½
16	18½	24	12	8
18	20½	27	13½	9
20	22½	30	15	10
22	24½	33	16½	11
24	26½	36	18	12
27	29½	40½	20	13½
30	32½	45	22½	15
35	37½	52½	26	17½
40	42½	60	30	20



*Plane of work (P) assumed to be 2½ feet above floor. When the plane of work is higher or lower than 2½ feet above floor, neglect column (F) and work from column (H).

**Minimum allowance for (R) usually 1 foot.

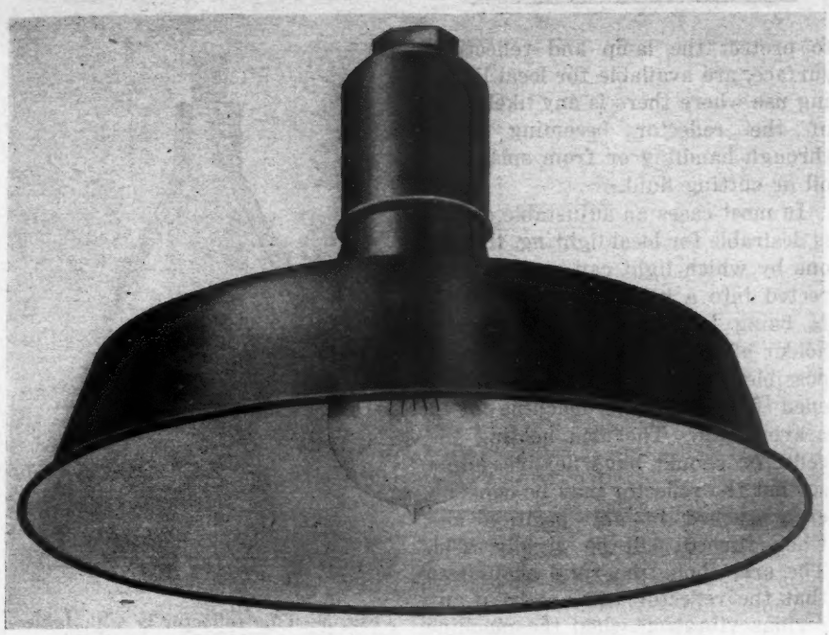


Fig. 2—The RLM-dome-bowl-enameled-lamp combination is suitable for a wide variety of industrial operations.

able latitude in the arrangement of machines and shop operations.

The dome type reflector, such as the RLM Standard Dome shown in Fig. 2, is ordinarily recommended for general lighting systems where the reflectors are around 9 ft. or more above the floor. The efficiency of these reflectors is good and when used with the bowl-enameled Mazda C lamp, the glare is minimized so as to be within practical limits. The shielding angle is such as to insure eye protection at ordinary mounting heights. However, where the reflectors are used at heights less than 8 to 10 feet above the floor, it is probably better practice to use the deep bowl type reflector which has a large shielding angle at a slight sacrifice of efficiency.

Group Lighting—The arrangement of machinery and manufacturing processes in some industries prohibits the use of general lighting in its broadest sense. These industries are the ones for which even natural daylight is considered deficient, not as to the amount of light but rather as to the direction of light to the work. Some of the typical industries of this class are shoe and leather goods manufacturing, the press rooms and composing rooms of many printing plants, and in general the textile industries. In all of these the direction of light to the work is fully as important as the amount of light on the work. The arrangement of outlets in a group system is suggested by the name; that is, the units or rows of units are grouped with respect to machines or rows of machines rather than with respect to the bay arrangement or building dimensions.

The greatest flexibility in a system of this kind is obtained where the lamps and reflectors are so spaced and mounted that a good general lighting system is left in case the group-lighted machines are replaced by machines of a different kind. For example, the system shown in Fig. 1 was designed for lighting groups of weave looms, but the units are so spaced and mounted that the effect of a very good general lighting system is obtained. With the looms removed it would be possible to substitute any one of the many manufacturing processes for which general lighting is desirable.

For installations where little or nothing is known about the arrangement of machines or benches to be placed in a room, it will be found advantageous to put the outlets on a closer spacing than the maximum allowable. It is then possible to tap into these outlets and place the reflectors in a semi-permanent position where they may be needed for a particular purpose. An example of this is found in the average printing plant composing room where each type bench and imposing stone should be lighted by at least one lighting unit directly overhead. Obviously, it would be foolish to set the outlets for such a system permanently in a concrete slab ceiling, especially as it is common practice in many composing rooms to move the type cabinets from time to time as other equipment is added. The semi-permanent reflector mounting device shown in Fig. 7 is easily tapped into a convenient outlet and has been successfully used for such requirements.

Local and General Lighting—Unquestionably local lighting has a legitimate application in some indus-

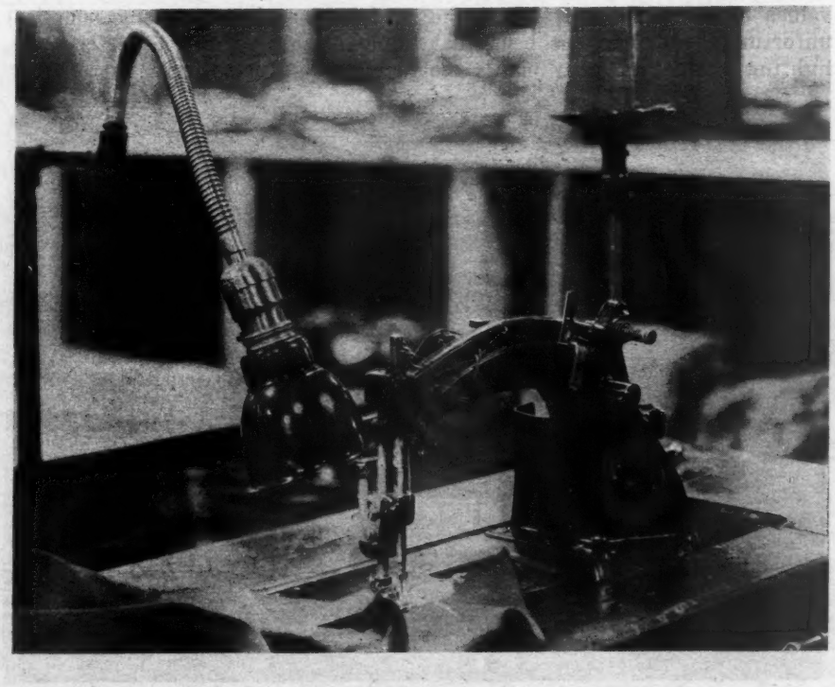


Fig. 3—A typical local lighting installation with deep bowl reflector and adjustable arm. This installation is supplemented by general overhead lighting of 9 foot-candles. The illumination at the needle is over 40 foot-candles.

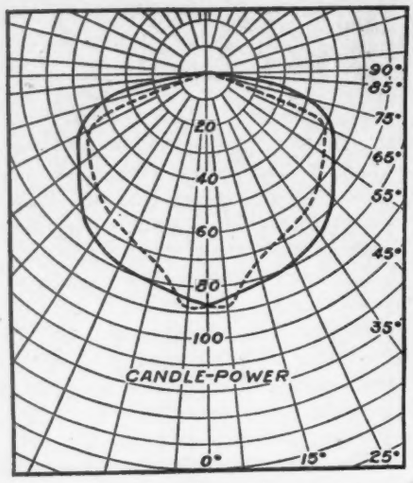


Fig. 4—Two distribution curves taken from the same reflector. The broken-line curve, obtained with the lamp filament just 1⅜ in. too high in the reflector, gives a reflector efficiency of 58 per cent. The solid-line curve, taken with the lamp filament in correct position, gives a reflector efficiency of 76 per cent.

tries. Typical examples are found in the lighting of sewing machines and automatic screw machines where the work is fine or dark and where as much as 50 foot-candles over a limited area may be necessary. However, even though a local light will take care of the work immediately at hand, a general overhead system giving say 6 or 8 foot-candles over the entire work area will be found economically good in the work of the entire department. Nothing is more disconcerting than trying to work when the lighting conditions force the eyes to be continually accommodating themselves to areas of high and low brightness. Here, the general lighting system has the additional advantage of flexibility, for if the locally lighted machines are removed, a good system of lighting still remains.

The type of reflector best adapted to local lighting is the small porcelain-enameled steel deep bowl shown in Fig. 3. It has a large shielding angle which is sufficient to protect the eyes when used in the normal position. Deep bowl reflectors with a recessed groove at the bottom which holds a glass plate in position so as to protect the lamp and reflecting surface, are available for local lighting use where there is any likelihood of the reflector becoming dirty through handling or from splashing oil or cutting fluid.

In most cases an adjustable device is desirable for local lighting, that is, one by which light can easily be directed into a hollow cylinder which is being bored or under the tool holder of a cutting machine. Where possible the device should be fastened firmly to the machine or a nearby wall. The arm holding the reflector should have flexible joints so that the reflector may be conveniently turned in any position and when turned will be rigidly held. The arm should be rigid enough so that the reflector will not have any serious vibration when the machine is working as the life of the lamp would be thereby shortened. Where it is impossible to eliminate all vibration the Mazda Mill-Type lamp is suggested. A small amount of efficiency is sacrificed to ruggedness in this type of lamp.

Fig. 5—This reflector is adjustable for lamps of different sizes but with the same base.

Wiring Capacity and Switching Arrangement

While it is important that proper lamps, reflectors, and outlet arrangements are used in the lighting system, the test of its flexibility is quite as often found in the wiring and switching.

It is not surprising that those who were installing lighting systems ten years ago did not anticipate the tremendous strides that illumination values have taken since then. The unfortunate outcome has been that lighting circuits in many plants are today far overloaded as larger and larger lamps are used to satisfy the natural desire for more and better illumination. In the textile industry it is now common practice to use a 200-watt lamp for the lighting of a group of four looms where ten years ago the 40-watt lamp was considered sufficient. Where colored or dyed materials are being worked there is an increasing tendency to replace clear lamps with Mazda Daylight lamps which require about 30 per cent more wattage for a given level of illumination. The result in many cases has been that because of overloaded circuits, lamps are being burned under voltage with decreased candlepower. This is uneconomical since a lamp burning 5 per cent under voltage has decreased 17 per

Fig. 6—A good lighting installation in a machine shop.

The lighting units consist of 300-watt Mazda C lamps in 20-in. combination glass-and-steel reflectors spaced on 10-ft. centers and give an illumination of about 20 ft.-candles. Small slots around the holder allow a certain amount of light to reach the ceiling. A glass globe within, and extending below the bottom of the reflector, cuts down the glare and also reflects light in the horizontal plane.

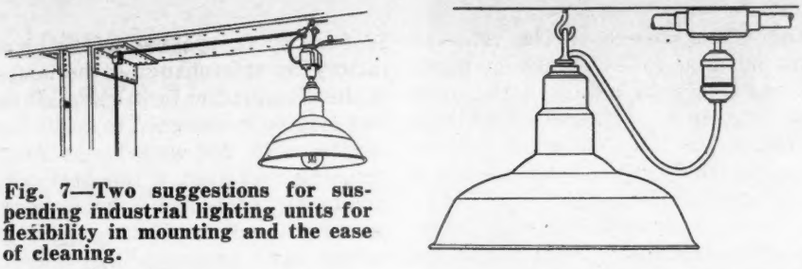


Fig. 7—Two suggestions for suspending industrial lighting units for flexibility in mounting and the ease of cleaning.

cent in light and has decreased only 8 per cent in wattage. So it is important in installing wiring today that the needs of the coming years be anticipated as far as possible. Table III shows that in many factories, natural daylight foot-candle values of from 20 to 35 are fairly common. The practice in several important industries today indicates that we are gradually moving toward similar values in artificial lighting.

Switching Groups—The answer to the switching problem usually lies in neither of the extremes commonly found; that is, all the units of a work area controlled by one switch, or an individual switch for each unit. Group switching properly applied will usually be satisfactory.

For example, in long, narrow buildings in which the machines are grouped in rows lengthwise of the building, the greatest flexibility is obtained if the lighting units are switched in groups or rows lengthwise of the building. Fading daylight can then be compensated for by turning on rows of units in the center of the room, and then gradually moving outward as the daylight recedes. In very large buildings or buildings which are nearly square, it is a good practice to switch the units in groups of two or four with the idea that four units will supply almost as much light to a man working in the center of the four as if the entire system were turned on. The arrangement of machines and windows will indicate whether the group should be in the form of a square or in a row.

TABLE II — Illumination Obtained from Several Sizes of Lamps Used in the Same Reflector (Fig. 8) with 12 ft. x 12 ft. Spacing — Average Factory Conditions.

Lamp Wattage	Foot-Candles of Illumination
500	24
300	13
200	8
150	5½
100	3½

Interchangeability of Lamps in Reflectors

The usual industrial reflector is of the dome type, is open at the bottom and is direct lighting, throwing the major portion of the light below the horizontal. Each size of reflector is designed for a particular shielding angle, efficiency and distribution of light only when the filament is in a certain position in the reflector. If the filament position is too low in the reflector the bright light source will be exposed to the eyes. If the filament position is too high, the reflector efficiency will be low. Photometric curves showing this condition are illustrated in Fig. 4.

There are only a few sizes of lamps which have the same light-center-length and may be interchanged in open type reflectors with a resulting illumination proportional to the light output of the lamp. Of these the 100 and 150-watt, the 300 and 500-watt, and the 750 and 1000-watt lamps may be interchanged with no change in light distribution or reflector efficiency.

In one reflector it is possible to interchange lamps which have the same size of base by merely adjusting the position of the reflector so that the filament bears the same relation to the reflector in each case. This is the prismatic reflector shown in Fig. 5. Marks on the stem indicate the position of the supporting collar to be used for the various sizes of lamps.

In local lighting reflectors it is possible to use the short light-center length Mill-Type lamp in reflectors designed for 50-watt vacuum lamps by the use of a regular 1⅜ inch socket extension, which brings the shorter light-center of the mill-type lamp into the correct position.

A new reflector (Fig. 8) has been recently designed, and is now commercially available, in which it is possible to interchange certain lamps without materially affecting the light distribution or efficiency. This reflector was designed through the co-operation of the steel and glass reflector manufacturers with the engineers of the lamp companies. It

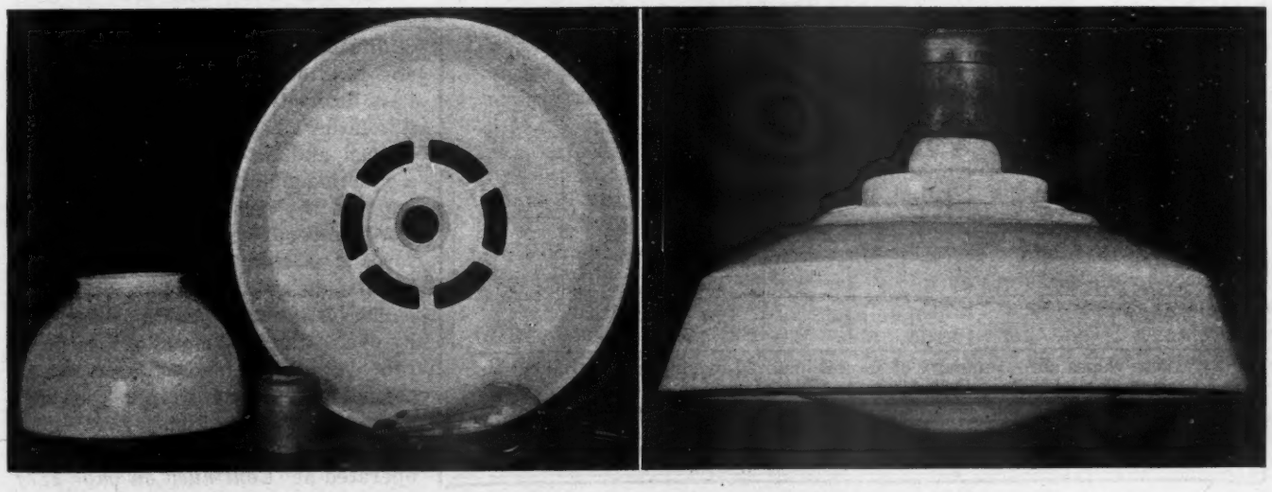


Fig. 8—A combination glass and steel industrial reflector which facilitates interchangeability of the lamps. An installation is shown on page 251.

is possible to use the 200-watt, 150-watt or 100-watt lamp with a socket adapter in the reflector designed for 300 and 500-watt Mazda C lamps. The illumination in each case is, of course, in proportion to the light output of the lamps. That is, a 500-watt lamp in the reflector gives approximately seven times the illumination obtained with a 100-watt lamp in the same unit. This reflector can be used to advantage in many plants where the nature of the work is frequently changed, requiring more or less light. A good installation of this unit is shown in the photograph on page 251.

Table II shows the average maintained illumination which can be obtained from these reflectors on a 12 ft. x 12 ft. spacing in the usual factory by interchanging the lamps. If the illumination for a certain area was originally designed to be 13 foot candles with 300-watt lamps for a grinding operation, a 100-watt lamp giving 3½ foot-candles could easily be substituted should the space be turned over to rough assembly or storage purposes.

TABLE III—Working Levels of Daylight Illumination in Foot-Candles * *

Factory Products	Foot-Candles	Grade of Work		
		A	B	C
Engine lathes	Horizontal Vertical, Min.—Max.	10 6—15	7 2—15	3 0.5—9
Automatic engine lathes	Horizontal Vertical, Min.—Max.	14 2—30	12 2—30	10 1—15
Machined forging	Horizontal Vertical, Min.—Max.		6 2—15	5 1—10
Special machinery	Horizontal Vertical, Min.—Max.	10 4—20	7 3—15	
Lamps	Horizontal Vertical, Min.—Max.	10 5—16	9 11—15	
Vacuum cleaners	Horizontal Vertical, Min.—Max.	17 7—25	11 3—20	
Automobiles	Horizontal Vertical, Min.—Max.	5 2—11	5 2—8	5 3—11
Automobiles*	Horizontal Vertical, Min.—Max.	10 6—12	3 1—3	5 4—5
Storage batteries	Horizontal Vertical, Min.—Max.		5 1—6	3 0.5—5
Machine tools and patterns	Horizontal Vertical, Min.—Max.	6 2—16	9 3—35	
Sheet iron equipment	Horizontal Vertical, Min.—Max.	10 1—20	5 1—12	8 2—15
Machine gears	Horizontal Vertical, Min.—Max.	7 3—16	8 5—18	5 1—15
Hardware	Horizontal Vertical, Min.—Max.	10 1—20	10 1—20	4 0.5—12
Printing machinery	Horizontal Vertical, Min.—Max.		5 1—15	3 0.5—5
Sewing machines	Horizontal Vertical, Min.—Max.		4 1—8	2 2—5
Cloth bags	Horizontal Vertical, Min.—Max.		5 3—10	7 3—10
Clothing	Horizontal Vertical, Min.—Max.	10 10—20	4 7—15	
Furniture	Horizontal Vertical, Min.—Max.	5 3—20	5 0.5—12	
Average	Horizontal Vertical, Min.—Max.	10 4—18	7 3—15	5 1.5—10

**These values are a summary of several hundred readings made to determine the level of daylight illumination in a number of representative manufacturing plants.

*Saw tooth roof.

Servicing Industrial Transmission Belts

(Continued from page 240)

is not necessary to rivet them, as rivets only decrease the strength of the belt by taking away some of the cross-section area, and also make a stiff place when going over small pulleys. If the joint does not stick it is usually because it has not been applied properly or the belt is too full of oil. How single and double leather belts are cut and joined is shown in an accompanying illustration.

How Fabric Belts May Be Made Endless

Fabric belts, solid woven cotton and camel's-hair belts excepted, can be made endless at industrial plants when applied, but not so smooth a joint is obtained as with cemented leather belts or if the fabric belts are made endless at the factory. Two sketches reproduced in this article show how a 4- and 5-ply canvas, rubber or Balata belt may be joined. The method of doing this is described in the caption under the illustration and will not be repeated here. The manufacturers of these belts, however, recommend that after fabric-base belts are cemented together, they be stitched or riveted so as to strengthen them, and also to hold down the plies. After this is done it is difficult, however, to open the belt and take out a very short length if it is desired to again shorten them. A leather belt, however, may be opened and as small an amount as a fraction of an inch may be taken out and the belt re-cemented.

Wherever possible, as stated before, it is best to make all leather belts endless. A comparison of an endless belt and a similar belt joined by one of the best metallic fasteners, properly applied, showed a decreased capacity of about 15 per cent for the one with the fastener. Where the load is not too heavy or the belt operated at *(Continued on page 277)*

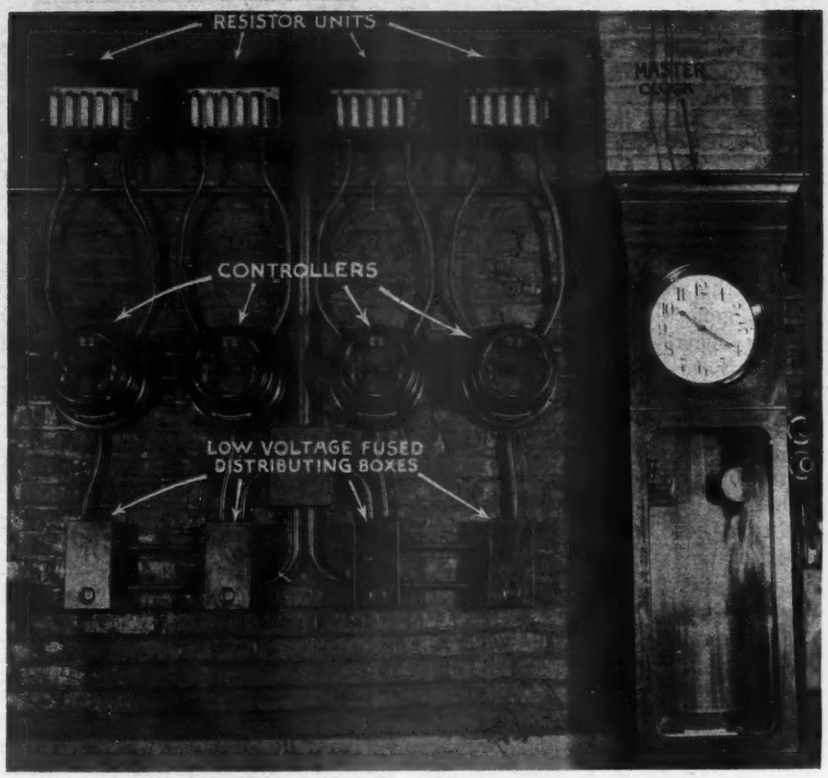
Operating Details of

Low-Voltage D.C. Control

Which has Insured Reliability and Low Operating Cost for Signal Systems

By PAUL F. CLAUSEN

Chief Engineer, Lyon & Healy Inc., Chicago, Ill.



This shows four of the eleven controllers which supply low-voltage current for operating the extensive sprinkler and fire alarm, electric-clock and signal service systems described in this article.

DURING THE past two years important changes have been made in the source of supply of low-voltage current for operating the sprinkler and fire-alarm, telephone, clock and other systems in the Lyon & Healy store and factory. These changes have resulted in such a marked decrease in operating and maintenance expense and trouble, with an equally marked increase in reliability and freedom from interruptions of service, that an account of what was done may be of interest to the readers of INDUSTRIAL ENGINEER who have conditions and problems similar to ours.

The store is in a ten-story building and requires an extensive alarm and signal service, as will be seen. The fire alarm system comprises two pull boxes and one 10-in. alarm bell on each floor. The alarm boxes are of the usual closed-circuit type through which a small current flows constantly. Through these boxes the alarm is sent in to the city fire department. The building is also equipped with a sprinkler system for fire protection. There are approximately 180 sprinkler heads on each floor. Two wet risers supply the sprinklers in which water pressure is constantly maintained, and one so-called dry riser is connected to the sprinklers in the display windows. All of these risers are equipped with switches whereby the alarm bells throughout the building and in the engine room in the basement are rung whenever a sprinkler head is opened either accidentally or by a fire. An annunciator in the engine room indicates the riser from which the open sprinkler is fed.

CURRENT FOR OPERATING electric clocks, fire-alarm, signal bell and other low-voltage systems is usually obtained from wet- or dry-cell batteries, or small motor-generator sets. Among the disadvantages connected with the use of these sources of supply is the possibility of complete failure of service through the development of trouble which may not be detected until the batteries are exhausted, as well as the amount of attention required and the expense of recharging or replacing exhausted cells. In this article Mr. Clausen describes the use of a device for reducing 110-volt direct current to any desired voltage and shows how an investment of $1,500 in equipment has made possible a saving of about $3,500 a year in operating and maintenance costs.

Correct time is shown throughout the building by an electric clock system consisting of one master, one program and thirteen secondary clocks. The program clock automatically rings a 6-in. bell on each floor at the time for starting work in the morning, at the beginning and end of the noon hour and at quitting time at night. The secondary clocks are, of course, operated and controlled by the master clock in the engine room.

There are in operation five passenger elevators, arranged in one bank of three and one bank of two, in the front and rear of the building respectively, and four freight elevators. Of the nine elevators seven are equipped with annunciator signals. The other two elevators are used only intermittently for carrying heavy freight. Annunciators on the passenger elevators have polarized target signals so that although a signal from any floor is registered on all of the elevators in that bank, the target is automatically restored as soon as any one of the elevators passes that floor. That is, when the button is pushed on the eighth floor, say, at the front of the building, the corresponding target in the annunci-

ators of all three elevators registers the signal. If, then, elevator No. 2 is the first to stop at that floor, the target in the annunciators of elevators Nos. 1 and 3, as well as 2, is automatically restored. These annunciators require that the current flow sometimes in one direction and sometimes in the other, in order to restore the polarized target.

For general signaling purposes, calling officials to the telephone, and so on, there are on each floor two bells, one in the front and the other in the rear of the building. Two pushbuttons on the telephone switchboard enable the operator to ring either set of bells as desired. In addition there are about 175 buzzers and annunciators for summoning stenographers, office boys and clerks in various parts of the building.

The second floor is devoted to the demonstration and sale of Victrolas and for this purpose thirty-six sound-proof booths have been installed. To avoid confusion in assigning booths to prospective customers, use is made of a signal board which has been found very satisfactory. This board consists of a metal box with a ground-glass front on which are painted the numbers from one to thirty-six. Behind each number is one white and one red 5-watt, 12-volt lamp. When the customer enters a booth and closes the door, a door switch makes contact and lights in the signal board the lamp corresponding to the number of the booth. The dispatcher thus knows at all times which booths are occupied. Within each booth there is a pushbutton and a buzzer. If the customer desires additional records or other service, the salesman pushes the button, which lights the red lamp in the signal board corresponding to the number of the booth, and also lights a 5-watt lamp above the door of the booth. The attendant at the board is thus notified that something is wanted and sends a clerk to render the service desired. The white light above the door not only helps the clerk to find the booth quickly, but enables the floor manager to see that service is rendered promptly. The light is switched off by the salesman in the booth as soon as the desired attention has been received.

A part of the fourth floor is devoted to the sale of player pianos, and for demonstration purposes there are fourteen booths similar to those on the second floor and with the same signaling equipment.

Finally, we have an 8-station intercommunicating telephone system between the various departments. This system is of the common battery type and requires 17 volts for operation.

In addition to the store this company operates a large factory for the

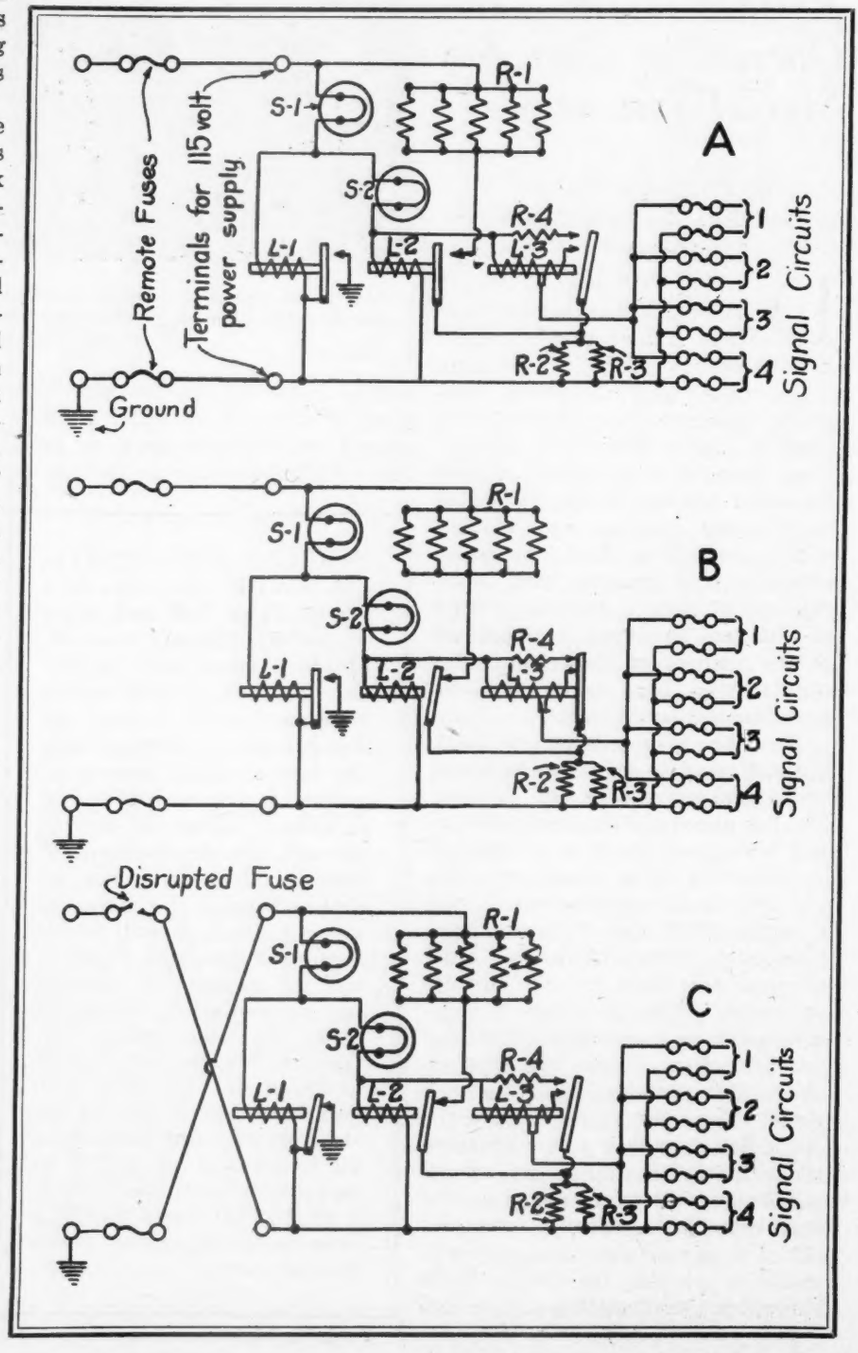


Fig. 1—This shows the operation of the controller under three different service conditions.

With the low-voltage side on open circuit, *A*, the connection is through lamps S^1 and S^2 and relay L^2 with a potential tap between S^2 and L^2, through L^3 to the positive side of the low-voltage circuit. The voltage on this circuit is determined by the relative resistance value of the two parts on either side of the potential tap. When the low-voltage circuit is closed, relay L^3, which has a double winding, is energized with a current of about 0.020 amp., causing the double contact to close, which reduces the voltage on relay L^3 and thus releases it. A connection is thus established through R^1, relay contact L^2 and resistances R^2 and R^3 in parallel. With the potential tap between the L^2 contact and the resistances R^2 and R^3 the operating potential of the low-voltage circuit is determined by the ratio of R^1 to the joint resistance of R^2, R^3 and the load. The resistance of R^2 is kept uniform while that of R^3 is varied to obtain the voltage desired. Relay L^1 for reverse-polarity protection is normally open so long as 110-volt power is on. If power service is interrupted and then resumed with reverse polarity or if polarity is reversed in connecting the controller, the contact of L^1 is closed and a ground connection made to the normally grounded supply main. This results in a short circuit and the blowing of the fuse in the power supply lead, as shown in *C*.

manufacture of pianos, harps and a number of other musical instruments. This factory is in a 3-story building which is equipped with a sprinkler system fed by three wet risers and one dry riser for that portion of the system which protects the dry kilns and shipping platform.

The current for operating these various low-voltage electrical systems was formerly obtained from three small motor-generator sets supplemented by dry cells and storage batteries. On open-circuit work approximately 150 dry cells were used while the closed-circuit system, as well as the house bells, buzzers, annunciators, booth signals, and so on, were supplied by two 6-cell, 120 amp.-hr. storage batteries. One of the motor-generator sets, of 65-amp. capacity, was employed for charging these batteries, which were used alternately; that is, while one battery was in use the other was being charged. This generator was in service from eleven to twelve hours daily. The elevator signals were operated from two small motor-generator sets which reduced 220-volt direct current to 17 volts. Although this was found to be a fairly satisfactory method of obtaining low-voltage current, oiling the sets and keeping them in proper condition took some time, and in addition they frequently ran very hot, generally from grounds which often developed in the system and drew a comparatively heavy current. Once every year or two a set would burn out and we would be put to considerable trouble, as well as the expense of having the set rewound.

With the batteries, too, considerable trouble was experienced. In the first place, the expense of replacing the dry cells and recharging and maintaining the storage batteries was considerable. Besides this, grounds often developed on the various systems and by the time they were discovered the batteries were often completely exhausted and, in the case of the dry cells, had to be replaced. Under these conditions we could seldom or never be sure that the sprinkler alarm system was in working order, for serious trouble could, and has, developed within a short time after the system was tested and found to be in good condition. If the alarm fails to sound on the accidental opening of a sprinkler head, many thousands of dollars damage might be done to the stock of pianos and other fine instruments before the break was discovered and the water shut off. Furthermore, it was necessary nearly every morning to set each of the secondary clocks by hand, as trouble or lack of power during the night had put the clock system out of commission. Although the batteries could not, of course, be blamed for trouble in the wiring, the expense involved and the attention necessary together with the uncertainty of the service, due to the fact that trouble could develop without our knowledge, made their use far from satisfactory.

After an investigation, and with the Underwriters' approval, it was

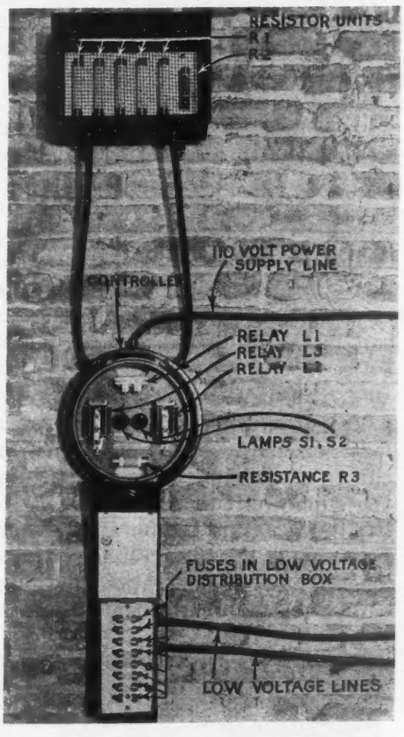


Fig. 2—Here is the way the controller, resistance unit and low-voltage distribution box are usually installed. This illustration also shows the relative position of the parts referred to in Fig. 1.

finally decided to install what is known as the Universal Electric Controller. This is a device designed for the purpose of reducing direct current at 110 volts to low-voltage direct current for the operation of any apparatus or system such as fire alarms, telephones, bells and the like, which are ordinarily operated by batteries or other sources of low-voltage current. For this purpose the instrument, which is a potentiometer, resistance appliance, is connected to a direct-current light or power circuit of 110 volts or more.

As will be seen from the accompanying illustrations, the equipment is arranged for convenience in three units, consisting of the controller or instrument proper, the resistance and a fused distributing cutout box into which the various low-voltage signal or other circuits are led. The controller is contained in a cylindrical case, the rear half of which is of cast iron. The front half is formed from sheet steel, with a flanged edge engaging the front of the cast-iron section and is fitted with a glass window. This case is 10-in. in diameter and approximately 6 in. in depth, the glass front having an opening of 7 in. The relays, resistors and terminal parts are mounted on ½-in. transite asbestos bases separated from the metal back of the case to provide wiring space. The resistors are all of wire wound in grooves on lava tubes. The ferrule terminals are of such size as to fit standard 60-amp. cartridge fuse cutout parts which are mounted on the base.

The resistance and distribution units are inclosed in sheet steel boxes of standard cutout type, with the resistance unit provided with a wire screen cover to afford free ventilation. The resistance unit is 12-in. x 8-in. x 4-in. in size with strap supports that provide air spacing of 1½ in. at the back. The distribution unit is supplied with special glass tube fuses and terminals for four circuits mounted in a steel box 9-in. x 5-in. x 3½-in., with a hinged cover and latch. By this arrangement it is not necessary to open the case containing any contacts directly connected to the lighting or high-voltage circuits in making the connections for the bell or other circuits. In the installation of this device which operates, of course, on a 2-wire circuit, one side of which is grounded, it is necessary to observe definite polarity connections. The controller will not operate when the polarity is reversed. Referring to Fig. 1, *A*, the circuits are seen to be arranged in a double potentiometer connection with an added connection to relay L^1 for reverse polarity protection. This connection is a constantly closed circuit and the relay does not function except on reversal of polarity.

The first or higher resistance potentiometer connection is through S^1, S^2, L^2, with potential taps between S^2 and L^2. This is also a constantly closed circuit. The voltage thus impressed on the signal system when open is determined by the relative resistance values of the two parts on either side of the potential

taps. That is, if the resistance toward the ungrounded supply main is four times that of the resistance toward the grounded main, then the voltage toward the ungrounded main is four times that of the voltage toward the grounded main. This latter voltage is that which is impressed on the signal system terminals. Thus there is about one-fifth part of the line voltage on the signal system with the normal open signal circuit condition.

The high resistance potentiometer connection affords supervisory voltage with a small power loss.

With a closed-circuit signal system the current energizes L^3 and with a value of about 0.020 amp., causes the closing of its double contact. This results in a lower voltage on L^2 with a lessened current which causes L^2 to release, as shown by Fig. 1, *B*.

The second or lower resistance potentiometer connection through R^1, relay contact L^2 and resistances R^2 and R^3 in parallel is then established with its potential taps between the L^2 contact and the two resistances in parallel. The potential taps of the two potentiometer connections are thus joined through the contact of L^3. The purpose of the additional winding on L^3 is to obtain a greater pressure on its contact by means of the additional magnetic pull.

The operating voltage of the signal system is determined chiefly by the ratio of R^1 to the joint resistance of R^2, R^3 and the load. With 115 volts impressed on the device and R^3 removed, the voltage impressed on the signal system decreases from 24 volts to zero, with increase of signal load. The value of R^2 is made uniform for all instruments of the type described here. Resistance R^3 is employed to obtain lower operating voltages and is, therefore, selected in each case according to the voltage desired.

The operating characteristic has the two limiting conditions of current merely sufficient to operate the relay at maximum voltage and a maximum or short-circuit current at almost zero voltage. At both limits the power output is small and definitely limited. In other words, even on a short circuit the current flow cannot exceed a predetermined value. The maximum power output occurs with approximately one-half of the maximum voltage and one-half of the maximum current.

The reverse-polarity protective relay, L^1, releases with any interruption of the power supply. Its contact is thus closed and a local ground connection is made directly to the normally grounded supply main. Should power be resumed with reversed ground polarity, a short-circuit occurs which renders the device inoperative and causes the blowing of a circuit fuse in the supply power lead. This condition is shown in Fig. 1, *C*.

The two small lamps, S^1 and S^2, serve both as resistors and as visual signals. With a signal circuit open they are dimly lighted. With a signal circuit closed or in operation they are slightly brighter. With failure of power supply they are extinguished. Further, under service conditions the opening of the circuit in the grounded wire, as might be produced by the blowing of a fuse, causes the armature of relay L^1 to drop, thereby establishing a local ground connection. This, in effect, is the same as re-establishing the supply circuit and causes L^1 to lift its armature again, at the same time breaking the ground contact. This sequence of operation continues as a vibrating chatter until the neutral fuse is replaced. The controller thus indicates automatically the presence of abnormal conditions such as failure of power supply, blowing of the fuse in the ground connection, or shorts or grounds in the signal circuits.

Our experience in the use of one of these controllers as a source of low-voltage current for the sprinkler alarm system in the store was so satisfactory that altogether eleven have been installed to operate, in both store and factory, the various signal and other systems previously described. The illustration at the beginning of this article shows a bank of four 17-volt, 5-amp. controllers with the resistors and cut-out boxes. Controller No. 1 at the extreme left of the illustration supplies the current for operating the house bells, annunciators and general signaling equipment throughout the building.

Controller No. 2 operates the open-circuit sprinkler alarm system, whereby, in the event that a sprinkler head opens an alarm is sounded throughout the building and on a bell outside, to call the attention of the Watchman Service police, and an annunciator indicates the riser involved.

Current for the time-stamp and electric-clock systems is supplied by Controller No. 3. Controller No. 4 supplies energy for operating the booth signals. Inasmuch as there are fifty booths in all, making a total of one hundred and thirty-six 5-watt

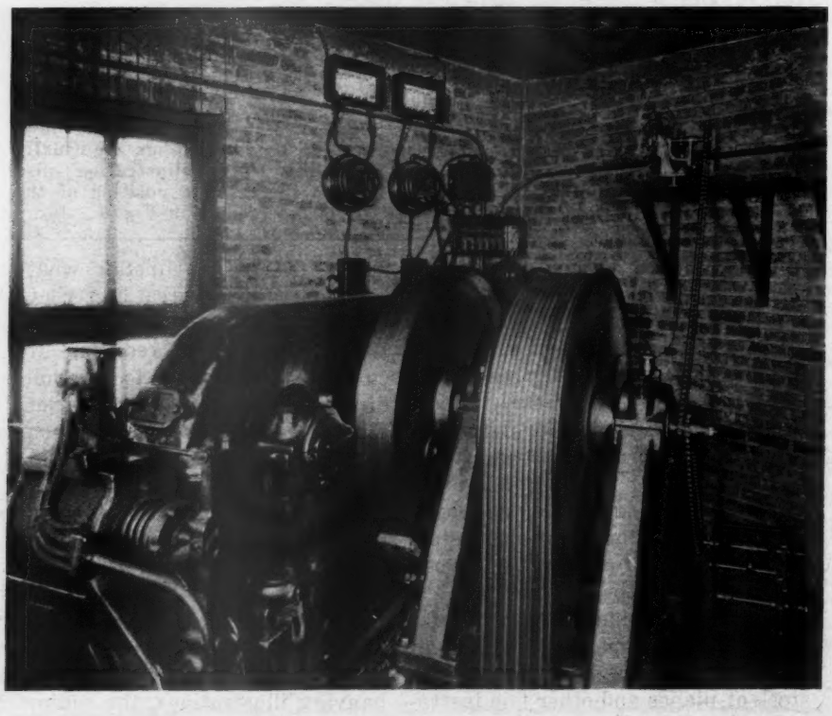


Fig. 3. These controllers replaced two small motor-generator sets for operating the signals of the passenger and freight elevators.

It was necessary to use two controllers, connected together to form a three-wire system, in order to operate the signals, which require a reversing current. One of the generators previously used may be seen below and to the right of the controllers.

red and white lamps, besides the buzzer signals, the possible load when all of the booths are occupied is beyond the capacity of the 5-amp. controller. Inasmuch as we had a 65-amp. motor-generator set which had been used for charging storage batteries and was in good condition, it was decided to use this for carrying booth loads which are too heavy for the controller. The circuits are now so arranged that by the use of two relays the motor-generator set is automatically started and picks up the load when this reaches 5 amp. The controller is at the same time disconnected on the low-voltage side.

Mention was previously made of the fact that the elevator signals require that current flow sometimes in one direction and sometimes in the other. This condition was met by using two controllers, shown in one of the illustrations, connected together. It is, of course, very essential that there be no interruption to the elevator signal service. For this reason the circuits were arranged so that the signals can be operated also from the 25-amp. motor-generator sets formerly used for this purpose, in case of trouble with the controller. There has, however, been no reason to switch over to these sets since the controllers were installed, nearly two years ago.

As one low-voltage system after the other was taken off the batteries or motor-generators and put on the controllers, we found that our operating and maintenance costs for the kinds of service indicated above were being reduced to a small part of what they were previously. The controllers require no attention whatever, so that maintenance is now mostly a matter of clearing an occasional ground or short circuit on the alarm and signal systems. By reason of this fact we were able to dispense with one troubleman and thus affect a saving of approximately $1,500 a year. On account of the greater reliability of the sprinkler alarm system, the insurance companies allowed a reduction which amounts to many hundreds of dollars a year on the premiums for insurance against damage by water from accidental opening of sprinkler heads, both in the store and in the factory. There is a further saving of nearly $800 a year in the power which was formerly used in charging the storage batteries. Altogether, it is estimated that a saving of $3,500 a year is being realized on an investment of about $1,500 in controllers.

Results of Careful Inspections

(*Continued from page 235*)

mounted on a cast-iron pedestal, with contactor switches placed at one side and held on a panel with sheet-iron guard and ample ventilation as indicated. A ½-hp., 220-volt motor drives the press, and starting and stopping is governed by a lever within easy reach of the operator. The lever connects with a switch in the conduit line shown and is arranged to release a mechanical brake when the power is thrown on. Such machines were formerly group-driven from overhead and the elimination of belting and shafting is a decided gain to the department.

A typical guard for a motor starting contactor group and switch as designed for Dennison service is shown in this illustration and another in *D* of Fig. 4. This guard is of metal, and is open at the sides and bottom to insure ventilation. A hand-hole for the speed control switch is shown, and at the top of the panel is mounted the push-button control. The motor in *D*, of Fig. 4, is mounted on a bracket designed for this machine by the company's engineers. Rigid conduit protects the wiring and insures compactness of layout.

Noteworthy saving in space is made in the case of a gear drive of a printing machine (not shown), from a 3-hp., 220-volt motor, speed 825 r.p.m. The motor is mounted on a cast-iron bracket about 5 ft. above the floor, and is geared through a rawhide pinion to a flywheel gear mounted on the main driving shaft of the machine. This arrangement represents the last word in compactness in gear driving, and it combines space-saving qualities with quietness of operation. The motor is lined up with fiber shims and fiber washers are used under the bolts to prevent electrical leakage. Push-button control is provided, with start and stop buttons at each end and in the middle of the machine on either side. These machines were formerly driven from overhead line shafts. Under the new arrangement there is no chance for oil and dirt to drip upon the product in process from the overhead belting, and the mounting of the motor at the end of the machine and at the height above indicated greatly facilitates inspection. The wiring is protected in rigid conduit and the contactors and resistance are well housed at one side.

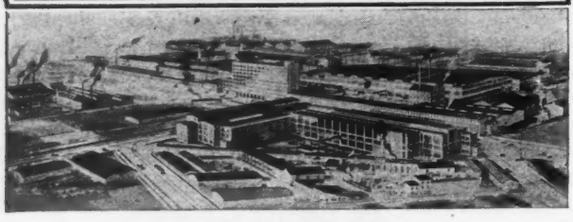
Excellent protection of motor and driving belt, with unusual compactness of wiring are achieved in the case of a Knowlton & Beach staying machine (not shown) individually driven by a 1/3-hp. motor. A bracket at one side carries the motor and extended strap-iron pieces support the conduit riser from the floor, the fuse block and snap switch for motor starting and stopping. The belt from the motor shaft pulley to the machine shaft is completely inclosed and a cylindrical extension piece hinged at the top guards an extension of the main shaft. The motor is fed by a short run of wire in circular loom from the condulet outlet beneath the oil guard.

A group of protective and control services mounted on one column in one of the productive departments is shown in *B* of Fig. 2. Here are centralized a local interior fire-alarm box, a watchman's signal box, a motor switch and speed control for a near-by power unit, a thermometer, a fire-alarm and signal gong, and a chemical extinguisher.

In conclusion, a few words may be added about the problem of illumination. The Dennison company is making a study of the desirable intensity of illumination to be used in various parts of the plant, and in general the tendency is toward increasing the former values. Where from 2.5 to 5 ft.-candles formerly were utilized, the tendency is toward using 5 to 10 ft.-candles. In the offices 200-watt lamps are being replaced by 300-watt units, and from 8 to 9 ft.-candles are being scheduled. In the company's new factory just being completed at Marlboro, Mass., an intensity of 8 to 10 ft.-candles will be utilized on the work tables in jewelry-box manufacture, and about 5 ft.-candles around box machines, slitters, etc. In the wiring there is a policy to subdivide the service to permit throwing on interior lamps before locations nearer the windows require artificial illumination. In typesetting, the intensity is being raised from 5 to about 8 or 9 ft.-candles. No more drop lights are being installed in the plant, and the use of metal reflectors has not been found as satisfactory as the utilization of prismatic shades, with their pleasing distribution in connection with light-colored walls and ceilings.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories



DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT E. H. HUBERT F. E. GOODING

Chicago, May, 1923

There Are No Snakes in Ireland!

MANY MEN responsible for maintenance and operation in industrial plants are looking for the perfect belt joint suitable for all purposes. However, like the snakes of Ireland, there are none. Of the dozens of belt fasteners which are available, and many of them good, perhaps none can be classed as the best for every purpose. In the case of belt joints, as with almost every other trouble-maker, one of the best methods is to eliminate the joint, or in other words, make the belt endless. This, however, is only practicable with leather belts, and even then, not under all operating conditions. On a belt put in temporarily or where the pulley diameter is changed frequently, as on some grinders to take care of decreased diameter of wheel and in similar locations, it is often doubtful whether or not the cemented joint is the most practicable. In many cases, as with side belts on wood planers or other places where uneven spots in the belt are not desirable, endless belts are usually more satisfactory and may be made so by the belt manufacturer so that the plant man has only to install them. In many cases these belts have idlers or tighteners to maintain tension and take care of any slight stretch. If the belt length is determined properly, usually but little stretch occurs with a first-quality leather belt. An endless belt is, at least theoretically, uniform throughout, that is of equal strength, equal width, equal thickness and uniform flexibility. Some of these qualities, however, must be sacrificed in using any other type of fastener. In addition, fabric-base belts cannot be satisfactorily made endless on the job, without sacrificing flexibility.

To overcome one of the greatest objections to endless belts—the time required to make the joint on the job—many metallic fastenings are offered to belt users. Due to the speed and ease with which they may be installed and their reliability, if the proper sizes and types are put on with enough care and workmanship to not be ashamed of, metallic lacings are increasing rapidly in popularity. Some examples of workmanship any maintenance man should be ashamed of are shown on page 238 along with some he can be proud of.

The Dark Horse in Production Control

IN EVERY industrial works a schedule of production is as essential as the orders on which it is based. But between receipt of the order and the shipment of the product there is a wide range of activity which includes the preparation and handling of raw materials at machines and between processes and departments so that when a production schedule is carefully laid out the essential parts will reach the point of assembly at the time needed and the product will arrive at the shipping platform with the fewest possible hitches and delays that cannot be foreseen at the start.

The greatest source of these hitches and delays can be usually traced to errors in judgment, disappointment in promises in the delivery of auxiliary equipment and parts purchased outside and unexpected delays in production through lost time, accidents and breakdowns in production equipment. In a plant that is rushed to capacity the losses from accidents and breakdowns may be so large and so serious that a production schedule which does not provide an adequate insurance against them through continuous inspection and attention to minor repairs before they become serious, will show a waste that will represent a large percentage of the possible profit on the work being handled. Here then is a weak spot in production control that is weakest when a plant is loaded with orders—a time when adequate thinking on continuity of machine operations and power service will show its greatest return.

In one large works the division of responsibility for continuous production is divided into three groups: (1) the engineering group "which tells how to do the job," (2) the production group "which tells what to do it with," (3) the manufacturing group "which does it." This plant has few breakdowns and few unexpected accidents for the group "which does it" has a definite organization "which keeps things going" in the process of doing the job. Here is the secret of production control in this plant and it's the same for any other, large or small. It's the "keep things going" group of men who know where reliability in systems and machines lies and from what kinds and types it can be secured. On their judgment and experience the "what to do it with" group draws when executing the division of responsibility in production that falls to them.

What Can Be Done in Fifteen Minutes a Day?

IT IS a common habit to belittle a loss or waste that appears trivial. A few extra inches of wire cut off and thrown away, five or ten minutes wasted in "visiting," or any of many other similar items, are ignored as of no consequence. Each waste by itself is a small matter but in the aggregate they amount to considerable. The commercial value of such trifles is well shown by the reported statement of a wealthy manufacturer of mustard dressings who said: "I did not make a fortune from the mustard people eat, but from that which they leave on their plate."

Wasted materials that show up as scrap or junk are easily seen. But many other wastes, such as lost time are less easily discovered and run into astonishing totals. For example, the value of only fifteen min-

utes of wasted time a day amounts to about $30 for each $1,000 in wages, or about the equivalent of a week and a half in a year. Those who ask "What can be done in fifteen minutes a day?" can find out by asking: "What can be done in a week and a half?"

Guessswork vs. Investigation

WITH the wide attention which is being paid to the problems involved in lighting industrial works, it is inevitable that mistakes will be made when the solution of some of these problems is attempted by men who have had little or no experience in this work. As a case in point the electrical department of a large works has lately revamped the entire interior lighting system by eliminating all drop lights and installing a localized-general system of illumination. Unfortunately the results have not been altogether satisfactory. The workmen in some of the departments are protesting vigorously that the new system is not giving them sufficient light and is, therefore, making their work harder. The head of the electrical department has met these complaints with the assertion: "Those old men think they are not getting any light unless they see a drop cord in front of their noses." There the matter stands. Each side thinks that the other is trying to "slip something over." Both contenders are holding their position firmly and the result is a situation that is not conducive either to harmony or maximum production. No one knows the real merits of the case—and that is just the reason there is a controversy. It is entirely possible that a few hours spent in taking foot-candle readings and interpreting these from the standpoint of what the illumination requirements for certain classes of work are, would show that more light should be allowed in certain areas. Up to the present no such tests have been made. Guesswork and stubbornness have taken the place of investigation. Arbitrary methods may be justifiable at times; however, as someone has said: "If you are sure you are right, go ahead—but first be *sure* you are right."

Work With a Chisel Instead of a Horn

WHEN the best you can say of a job is that it is good enough, and when a repair job looks like a countryman's harness all tied up with a string, you get a definite impression of the kind of thinking that men responsible for such work do, even though they seem to have the usual excuse of being too busy with other big jobs to attend to the details of the smaller ones. This is one sign of waste. There is another equally bad. It is found in those cases where a plant man spends much time and money in putting in super-refinements on a job, where a less expensive and less complicated layout would function equally as well, for the sole reason of being able to show his advanced ideas and the niceties of installation details and talks about these as evidences of his ability and knowledge of first-class work. The man whose engineering judgment is so warped by his good opinion of himself is not much better off than the one who is careless and sloppy, for both are wasters.

Between these two extremes is the man whose engineering judgment is based upon common sense, a thorough analysis of operating requirements and expected results checked against the costs plus maintenance service. He is the man who works with a chisel instead of a horn and leaves behind him evidences of business as well as technical thinking in the work he does that requires no long reports or elaborate data to justify the expenditures he makes.

Moreover, such a man when he carries the title of foreman, millwright or some such title that connects him with the details of some particular job, is not considered by his employer as in the labor group but in that division that carries responsibilities for production. In that sense he is an operating representative of the executive with whom he works—not simply one of a group working for this executive and paid for the time put in.

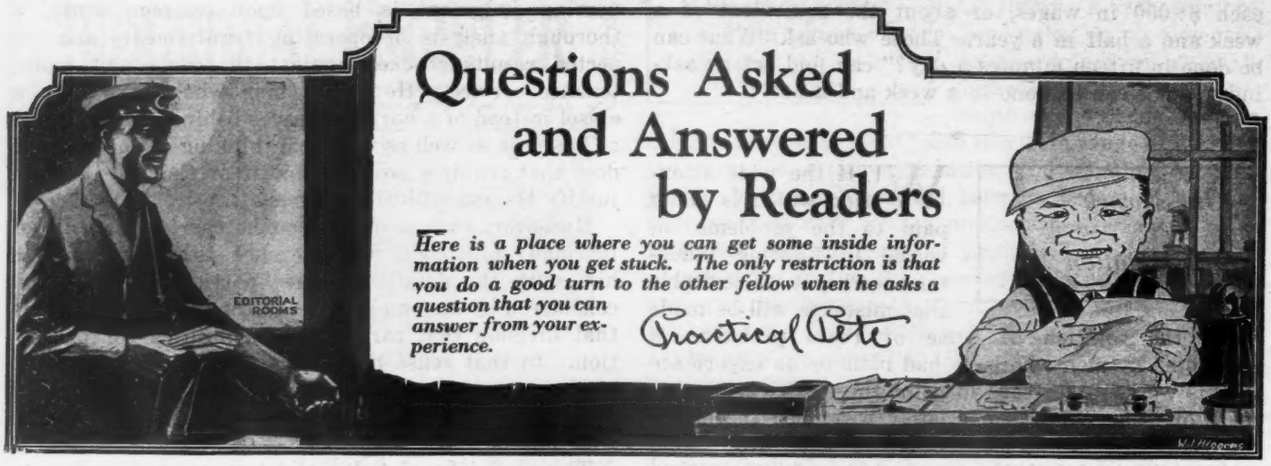
The good jobs of today and tomorrow are going to be held by the men who appreciate this viewpoint and show through their work that they appreciate their opportunity by exercising initiative and responsibility to increase production and control its cost. If such a man works with a chisel instead of a horn his work will be his testimonial for larger responsibility and the salary that goes with it.

Attention That Pays Dividends

WHEN A FIRE starts in a plant the attention directed toward getting fire fighting equipment into action is in keeping with the possible disaster that may result. This kind of attention pays dividends when a fire actually starts. But relatively few fires are disastrous in the full meaning of this word and the reason is directly attributable to fire fighting precautions.

In every works, large or small, normal wear and tear plus the results of indifference and carelessness set up conditions that result eventually in losses of the same order as the destruction caused by a fire. Results of wear and tear do not always show up on the surface and it takes a trained eye and ear to detect them in the early stages of their seriousness. When things are running nicely a man looking for trouble is too often viewed as a trouble maker but in the long run such a man skilled in his work, produces profits just as truly as the man at a machine who performs an operation in a process of production, for he makes it possible to get continuous production from that machine at a definite predetermined and uninterrupted rate.

In a large works, attention in the form of skilled inspection along the line of power service where the responsibility of machine operators neither begins nor ends at any particular point, makes it possible to know what spare parts are needed in case of a breakdown and just where to anticipate troubles without waiting for them to show up. Serious breakdowns rarely occur on battleships and locomotives on fast trains, because of precautions through inspection and the knowledge that small repairs of defects that look like trouble makers cost about 1 per cent of repairs that actual failures demand. Attention through inspection, therefore, turns the remaining 99 per cent of the possible repair expense into cash dividends.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete

Who Can Answer These?

Contact Points on Electric Bells—What is the best metal other than platinum, to use for contact points on electric bells and gongs? If several kinds can be used, will you please indicate the order of their suitability, as first, second, third, etc.?
New Orleans, La. P. B. A.

* * * *

Armature Insulation—What is considered the best types of slot insulation that varies from 5 to 10 mils in thickness, considering pliability, mechanical and electrical insulation and deterioration in stock?
Albert, W. Va. F. H.

* * * *

Cleaning Transformer Cores—Will some reader of INDUSTRIAL ENGINEER tell me what method he has found best for cleaning transformer cores that are to be rewound.
Americus, Ga. B. B.

* * * *

Current Drawn by Testing Transformers.—In the January, 1922, INDUSTRIAL ENGINEER page 45, there was shown a transformer for testing armatures. I wish someone would tell me just how many amperes this will draw on a 3-phase, 60-cycle, 115-volt circuit.
Murrieta, Calif. F. D. O.

* * * *

Winding a 1 to 1-Ratio Transformer—I want to wind a 1 to 1 transformer for 110 volts primary and 110 volts secondary and apply both primary and secondary wires at the same time. This would put the secondary winding in contact with the primary winding through the entire length with no other insulation between them, except that which is on the wire. What insulation would it require to withstand the stress for this kind of an arrangement? Would it require enamel and double cotton, enamel and single cotton or would double cotton be sufficient?

If I understand it correctly, when the primary pressure is a maximum the secondary pressure is zero, and when the secondary pressure is maximum, the primary is zero. Is this correct? If so, the emf. or current would not pass from one winding to the other, except when the secondary was grounded.
Logansport, Ind. L. E. G.

Object of Short-Circuiting Ring on Field Coils—Recently one of my men was retaping the field coils on a 10-hp. motor. These coils had a copper piece on the insulation the width of the coil and the coil wound on same. This assistant asked me the object of this construction. Is the following answer correct? When opening the shunt field there is a high inductive kick which this short-circuiting ring takes up and thus safeguards the insulation against puncture.
Chicago, Ill. V. L.

* * * *

Mounting Motors—Should electric motors run in a horizontal or vertical position? Is there any difference in their performance in such positions, from an electrical standpoint? Practical motor men have told me that motors in a vertical position do not give the same service and satisfaction as the ones operated in a horizontal position. Some argue that when a motor is running in a vertical position that the rotor centers itself in the magnetic field so that there is no more wear on the lower bearings than on the upper ones. What is the opinion of readers of INDUSTRIAL ENGINEER on this question?
Lancaster, Pa. K. M. C.

* * * *

Rewinding Desk Fans—We have to rewind 16-in. desk fans of Westinghouse and Colonial make, and I would appreciate if some of the readers will answer the following questions: How many turns and what size wire should I use for the armature coils? What is the coil pitch? There are twelve slots and twelve bars in the Westinghouse fans and fourteen in the Colonial. When the armature is mounted in the winding machine should the upper end be turned toward the operator or away from him when winding? Should the leads be brought out on the side nearest to the operator, or on the opposite side? What is the pitch of the commutator leads and does it make any difference whether I swing them to the right or to the left? This is a lap winding, and there is more wire in the last coil than in the first coil, assuming the same number of turns on all coils. Will this cause sparking at the brushes?
St. Louis, Mo. W. G. W.

Answers Received To Questions Asked

Trouble With Sparking at Brushes—Will you please answer the following and explain what the trouble is? We have a 500-kw. rotary converter which has for some time been giving trouble from sparking. The commutator has been turned down and slotted and still it is sparking. The spark is a light blue, leaving the brush on the leading side. It does not burn the commutator and acts like a static spark. It is not quite so bad when running with the compound switch in.

We have been over the field connections and everything else we could think of that would cause it to act this way. What do you think the trouble comes from?
Natick, Mass. J. A. P.

This will answer J. A. P. of Natick, Mass., on trouble with sparking at brushes. Examine the under armature leads where they fasten to the commutator bars. You will probably find some of them worked loose and making a poor contact. By resoldering them the sparking will be stopped. This proved effective on a 500-kw., 600-volt motor-generator set in our plant. EARLE N. DILLAN.
Chief Electrician,
Booth-Kelly Co.,
Springfield, Ore.

* * * *

How to Figure Ampere Rating of a Cable—How can I find the rating of a cable when I know the number of wires in the cable and the size of these wires? For instance, what is the rating of a cable that is made up of seven No. 14 wires?
Sartell, Minn. L. S.

Regarding the query of L. S. as to the ampere rating of a cable, to find the ampere rating of a cable multiply the cross-sectional area of an individual strand by the number of strands composing the cable. Thus for the cable of 7 No. 14 B & S wires we find from a wire table that the cross-section area of No. 14 B & S is 4107 circ. mils. $4107 \times 7 = 28{,}749$ circ. mils total area. From

the table we find this to be a value nearest to No. 6 B & S, which has an area of 26,250 circ. mils. For rubber insulation this is rated at 50 amps., and 70 amps. for other insulation.

J. B. RAKOSKE.
Detroit, Mich.

* * * *

In answer to the question by L. S. on cable rating, I find the simplest way to determine the size of a cable is to look up the circular mil area of the wires of which the cable is composed and multiply this area by the number of wires in the cable. Then look up the wire size which is nearest to the result in circular mil area.

As an example take the cable made of seven No. 14 wires. Reference to wire tables shows the circular mil area of No. 14 wire to be 4,107. Multiplying this by seven gives a total circular mil area for the cable of 28,749. From the tables the wire with the circular mil area nearest in size to this figure is found to be No. 6. This is therefore the equivalent size of the cable and it will have approximately the same ampere rating as a No. 6 solid wire.

This method can also be applied to making up temporary emergency cable as follows: A No. 4 wire is rendered useless in a cable run and the only wire on hand is found to be No. 10. Reference to the wire table shows the circular mil area of No. 10 to be 10,380 and of No. 4 to be 41,740. Four No. 10 wires will therefore be required to replace the No. 4.

Comerio Falls, FREDERICK KRUG.
Bayamon, Porto, Rico.

* * * *

In the March issue of the INDUSTRIAL ENGINEER, L. S. asks how to determine the carrying capacity of cables and gives, as an example, one of seven No. 14 wires. If he will refer to the Regulations of the National Board of Fire Underwriters, better known as the National Electrical Code, he will find his answer there under the heading "Standardized Stranding." The rating given there is 50 amp. for rubber insulation; 60 for varnished cambric; and 70 for other insulations.

In cases where the stranding is not given in the table mentioned above, it is possible to figure out the proper rating by looking up the circular mils in each of the strands and then multiplying them by the number of the strands, the sum being the number of circular mils in the entire cable. For instance, in the cable mentioned each strand has an area of 4,107 circ. mil, so that seven would have 28,749 circ. mil. A cable of this size would be between No. 5 and No. 6 wire and, in order to "play safe," the rating of the smaller wire should be taken. If the carrying capacity of a No. 6 wire is looked up in the National Electrical Code, it will be found to be the same as that given in the table for "Standard Stranding."

G. H. MCKELWAY.
Westfield, N. J.

* * * *

Elimination of Arc Lamp Noises—Will some reader please tell me how I can overcome the noise in a. c. arc lamps.

Bridgeport, Conn. G. R. C.

This will answer the question by G. R. C., Bridgeport, Conn., in the March issue on elimination of arc-lamp noises. The humming sound of an a. c. arc lamp is due to the expansion and contraction of the arc, caused by the rise and fall of the current. These variations produce vibrations in the air and a hum that varies in pitch with the frequency.

JOS. B. HUMPLEY.
Chief Electrician,
Blatz Brewing Co.,
Milwaukee, Wis.

* * * *

Trouble From Grounded Circuit.—Recently we were asked to look over a motor circuit for a school which had grounded all of the radiators in the school house. It was a 3-wire, 110-220-volt line entering the building in conduit with a grounded neutral on a pipe. We cut this ground and rung out the circuit and found no other grounds. As the motor does not run mornings we went away only to be called again in the afternoon. This motor is bolted on two pieces of wood in cement and has been running for four years and never given any trouble until this Spring. All the rest of the wiring was O. K. and we let the job go. There has never been anything done as the janitor gave instructions to keep hands off the radiators. What could be the possible cause of this trouble?

Saranac Lake, N. Y. L. J. R.

Regarding the trouble reported by L. J. R. of Saranac Lake, N. Y., in the February issue, since the test showed no grounds on the motor or house wiring when the grounded leg was open, I would suggest that test be made for electrostatic trouble, probably caused by the motor belt.

I presume the motor belt runs close to a radiator or some pipe of the heating system. The heating system is effectively insulated from the ground, and acts as a condenser for the static accumulation from the belt. When a pipe or radiator is touched, a discharge takes place through the person. The potential is so high that a dry wood floor is no insulator against it. The writer has made tests where static from an 18-in. belt jumped a gap of one foot past the full length of a 24-in. wood rule and severely shocked the person holding the rule.

The remedy is to place a metallic comb across the top of the belt and ground it. Also ground the heating system.

WILLIAM MCNALLY.
Brooklyn, N. Y.

* * * *

Device for Testing Windings of Small Motors—Will someone be good enough to describe a small testing transformer or similar device such as described on page 45 of the January issue of INDUSTRIAL ENGINEER, that can be used for testing the windings of fractional horsepower motors for short-circuits, grounds, open circuits, and the like?

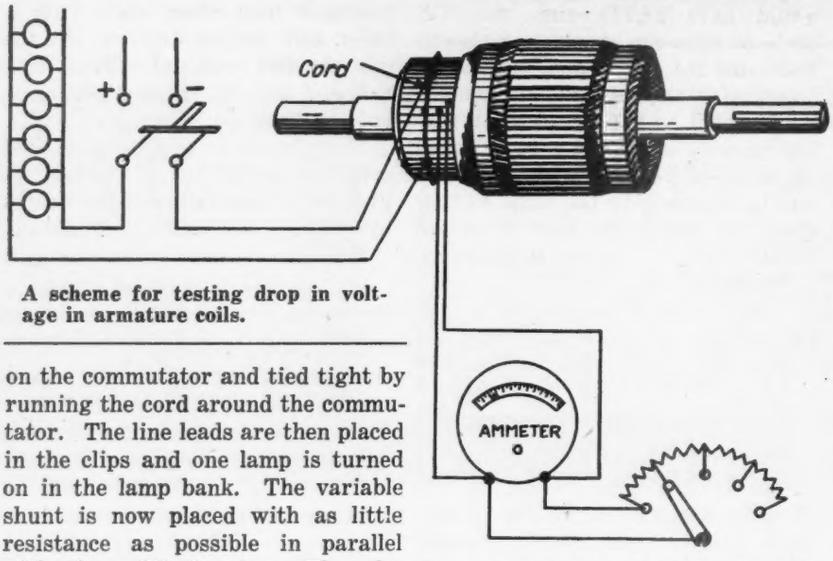
Nanty-Glo, Pa. S. J. S.

I have read with a great interest the articles published so far in "our" magazine concerning the testing of armatures, using the method of telephone receiver and battery, single lamp circuit and receiver, buzzer, etc., and feel that I can give you a better one yet, so I am here presenting a method which we use extensively with excellent results in the shop where I am employed.

The apparatus consists of a lamp bank of eight 120-watt carbon lamps, with test leads in series with the circuit, a pair of contacts to be attached on the commutator of the armature and a millivoltmeter with an adjustable shunt with leads coming from the meter binding posts. I am enclosing a drawing with all apparatus shown in position for use. The millivoltmeter we are using is an ammeter with the heavy shunt removed and a volt scale instead of an ampere scale so that the readings will be more noticeable, due to more divisions on the scale.

The contacts used on the commutator are made from $\frac{5}{8}$-in. round bronze, $\frac{3}{8}$ in. thick, with holes through them for a cord to pass. A small screw is put in the top of each contact to hold it in position on the cord. These contacts have to be placed at various distances apart, depending on the resistance of the armature being tested. The contacts are slightly concave on the bottom, to fit the commutator. Leads about 18 in. long are soldered on the contacts and at the other end of the lead a clip is fastened so that the live lines may be attached.

The method employed in testing is as follows: The contacts are placed



A scheme for testing drop in voltage in armature coils.

on the commutator and tied tight by running the cord around the commutator. The line leads are then placed in the clips and one lamp is turned on in the lamp bank. The variable shunt is now placed with as little resistance as possible in parallel with the millivoltmeter. Then by touching the leads which come from the meter binding posts on two adjacent commutator bars, the needle will be deflected. These leads should have sharp-pointed nails soldered to them. If the needle reads backwards, reverse the leads as you place them on the commutator bars. After noting the deflection of the meter in the proper direction, the reading may be increased by inserting more of the variable shunt winding in the circuit. This meter shunt is wound with a lot of small wire, about No. 22. This causes less current to flow in the shunt and more in the meter. If this does not give a high enough reading, another lamp may be inserted in the lamp bank.

When testing armatures that are wound with fine or comparatively small wire, we find that one or two lamps with the use of the shunt will give a very desirable reading. Where the armature is wound with heavy wire, several lamps must be used and many times the shunt winding must be eliminated from use with meter. This allows all the current to go through the meter. By varying the position of the contacts on the commutator, a different reading is obtained also. The nearer they are, the higher the reading, and vice versa.

The results obtained by using this method are as follows: When all coils produce the same reading, the armature winding may be considered in good condition. Where a higher reading is obtained than the regular reading, this denotes a poorly soldered connection or partial open circuit. A very high reading denotes a complete open circuit. Where a lower reading is obtained than the regular reading, it denotes a short-circuit, which may be in the coil or in the commutator. This method will not show small carbonized spots in the mica, but will show a slightly lower reading if the carbonized spot is producing a short-circuit sufficient to produce trouble under ordinary conditions.

When the armature is one where the coils are connected in series or as we know it, a (1) and (2) connection, the trouble will be at the place where the different reading occurs. When the armature coils are connected on the half, the different readings will be found on opposite sides of the commutator, and in the case of a short-circuit the reading will be two low readings on one side and one lower on the other side. The lower reading is where the trouble is. The same effect and result is found in the case of a poor connection, except that the highest of the three readings shows the trouble.

This apparatus may be used to show where a grounded coil is. The method employed is that the leads from the meter are placed, one on the shaft and the other on the commutator. The needle will read forward and backward as the meter lead is moved over the commutator surface. When the needle reads zero the grounded coil is found, although it may be necessary to move the contacts around the commutator in several places as in some places the needle will read backwards on one bar and forward on the next. When the lowest possible reading is found, the leads are lifted and the ground is found to be either in the coil or commutator.

When the armature is connected on the half, it will be necessary to lift leads on the opposite side from where the lowest reading is found, in order to release both ends of the coil from the commutator, so that a direct test may be made on the coil with the live leads.

This apparatus may also be used to check the resistance of shunt fields by putting each field in the circuit separately to see if they all read alike. This circuit is made by putting the field coil and meter in series with the lamp bank across the line. I feel sure that anyone who installs this apparatus will be amply repaid by the results, as it is used in our shop altogether as the means of testing all the armatures we rewind and repair.

Darby, Pa. GEORGE W. HANLON.

* * * *

Location of Starting Equipment for Synchronous Motor—We are about to install a 350-hp. synchronous motor on a circulating pump. Would it be practicable to install the starting equipment about 100 ft. from the motor at the main switchboard, although the man starting the motor would not be able to see it? However, a man standing about 25 ft. from the motor could easily signal the operator. The main switchboard is on a gallery above the motor and if possible we would like to have the switchboard operator handle the starting and stopping of the pump.

Hudson, N. Y. F. R.

In reply to the question by F. R. of Hudson, N. Y., as to the practicability of installing the control equipment of a synchronous motor on a switchboard out of sight of the motor, it is well to refer to Rule 8 on motor switches, page 20 of the National Electrical Code.

The last sections of section C on page 21 state that "the switch and starting device must be located within sight of the motor, except in cases where special permission to locate them elsewhere is given in writing." Also "when auto-starters are used, a switch * * * must be within sight of the starter or starters controlled."

The rules are made for the use of wiremen, and the reason, of course, in this case is to insure proper inspection of the apparatus every time it is put into service. If the man who starts the motor can see it, he unconsciously will look at it and notice any disturbance or unnatural actions. It is not advisable to install the apparatus in any other way.

Boston, Mass. E. A. GIBBS.

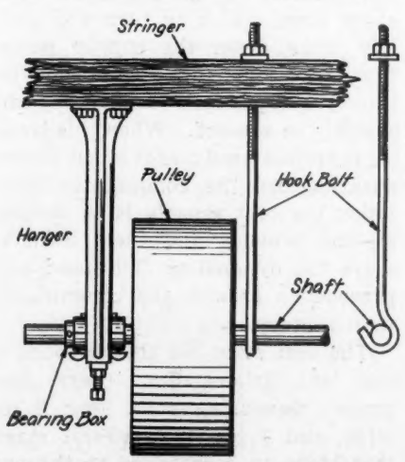
SERVICE
around the works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

Simple Method of Removing Solid Rim Pulley From Shafting

AN ELECTRIC motor was installed to drive the lineshaft in a pattern shop connected with a foundry. The lineshaft had previously been driven from the main shaft of an engine. The old driven pulley on the lineshaft was of the solid-rim type. To make room for a new driven pulley of the diameter required for the motor drive, it was necessary to remove the old pulley from the shaft. In order to do this, one of the shaft hangers had to be taken down.

The use of tackle for supporting the shaft in the absence of a hanger was avoided by first shifting the pulley close to the hanger and then suspending the shaft by means of a 1¼-in. hook bolt the upper end of which was inserted in a hole bored through a wooden stringer directly above the shaft, as shown in the accompanying illustration. The nut on the upper end of the bolt was tightened until the weight of the shaft was taken off the lower half of the bearing box in the hanger. The hanger was then taken down, the pulley slipped off the end of the shaft and the hanger restored to its place without disturbing the alignment of the shaft. A. J. DIXON.
St. Louis, Mo.



The shaft is supported by a hook bolt when the hanger is taken down to remove the pulley.

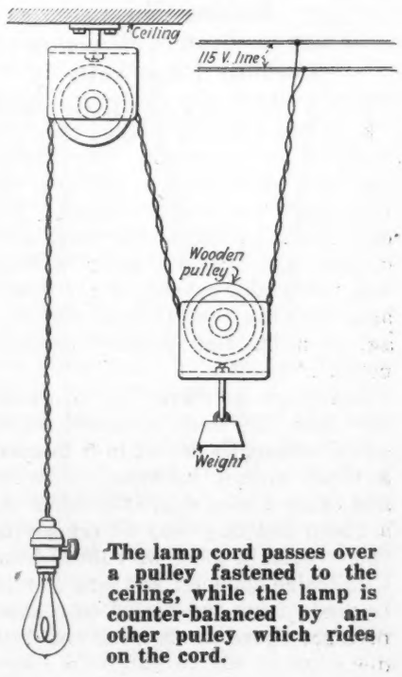
A Reader's Comment on Thawing Frozen Water Pipes by Electricity

IN THE March issue of the INDUSTRIAL ENGINEER, page 161 appeared an article on "A Simple Method of Thawing Frozen Water Pipes by Electricity." Briefly, the plan was to strip the insulation from the end of a wire for a distance of about 6 in., fasten the wire to a stick, and then partly re-insulate the end by wrapping cloth around it after this cloth has been soaked in salt water to make it of low resisttance. The other end of the wire is then attached to the nearest lamp socket through an attachment plug and the cloth-wrapped end held against the pipe. This causes a high-resistance ground and as the current flows heats the pipe.

The ordinary lamp socket is fused for only 10 amp. and sometimes only for 6 amp., so that the maximum current that could be obtained in this way would be very small; in fact, so little that it would have no effect on any but very small sizes of pipe, smaller than any that would ordinarily be used around a plant in any exposed place. While the plan proposed might work in some cases, ordinarily more current would be required than is obtainable from a lamp socket.
Westfield, N. J. G. H. MCKELWAY.

Simple Method of Mounting an Extension Light

OF THE many ways of mounting an extension light the method described below is perhaps as simple as any. This method of mounting requires only two wooden pulleys, one



The lamp cord passes over a pulley fastened to the ceiling, while the lamp is counter-balanced by another pulley which rides on the cord.

of which is fastened to the ceiling while the other rides on the lamp cord itself to counterbalance the weight of the lamp. It might seem at first that there would be an objection to running the lamp cord directly over the pulleys, because the bending and wear might be injurious to the cord and cause a short circuit. However, the cord on several extension lamps of this kind that have been used for the past four or five years shows less wear than in the case of most of the other devices, of which there are quite a number in use, including several which are on the market.

The extension devices which can be purchased of course take up less room, as they wind the cord on a reel and can therefore be mounted on the side of the wall or on a post. But some of them are not quite as convenient as they look and in addition are rather expensive. With the arrangement described here there is nothing except the lamp cord to get tangled and that is kept in place by the pulleys. If the pulleys are made fairly large, say 4 in. or 5 in. in diameter, the bending of the cord as it travels over the pulleys will not be injurious. Also, the strain on the cord is very light compared to what it is with some other devices. Care should be taken to provide the pulleys with a wide guiding strap or hanger, as shown in the illustration, so as to prevent the cord from running off the side of the pulleys.

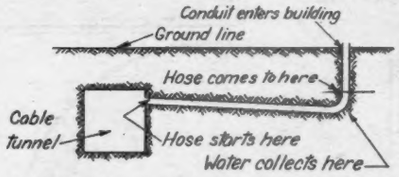
PHILIP E. BERNHOLZ.
East Orange, N. J.

Rubber Hose Used to Protect Wires in Conduit From Water

THE ACCOMPANYING sketch shows a simple method that was used to prevent water from shorting and grounding a 480-volt circuit which was laid in conduit. The duct line is of 2-in. Orangeburg fiber conduit and was put down without any protection or regard for drainage. The line runs from a cable tunnel to a building a short distance away.

Inasmuch as there was no drainage from the duct, sufficient water would frequently collect in it to make a short circuit between the wires and cause a good deal of trouble. As a cheap and easy way of remedying this trouble a piece of rubber hose, 1-in. inside diameter and long enough to reach from the tunnel to a short distance above the bend of the duct, was procured. The six wires in the duct were run through the hose and securely fastened and the hose then pulled into the duct.

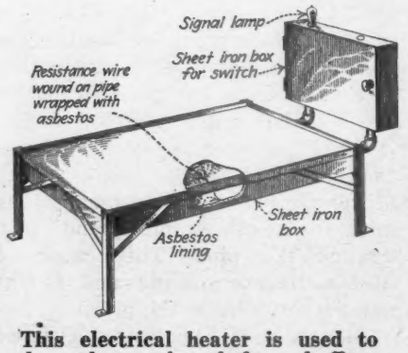
I realize that this method of overcoming the trouble may not be in accordance with all rules and regulations, but it served its purpose, for no further trouble has been experienced. Furthermore, it saved both time and money, which was an important consideration. F. G. F.
Ada, Okla.



The wires are encased in a piece of rubber hose, which protects them from water collecting in the conduit.

How to Build a Flat-Topped Electric Heater for Contact Drying

IN SOME manufacturing processes it is necessary to dry the work before performing the next operation. One example of this in the shoe industry is the drying of the soles before buffing. For this, one shoe factory uses the specially constructed, flat-topped electric heating device shown in the accompanying sketch. This is constructed with two large heating elements enclosed in a partially air-tight, heat-insulated sheet-iron box, supported by four angle-iron legs. All of the inside surfaces except the top of the box are heat-insulated from within by three ¼-in layers of asbestos. The 17-in. by 54-in. sheet-metal top which is made of No. 16 galvanized sheet and supported at the edges has a drying surface area of 918 sq. in. The heating elements consist of two 1-in. gas pipes 60 in. long wrapped with a layer of non-burn, sheet asbestos for insulating the coil of No. 12 Nichrome wire which is wound on the pipe the length of the containing box. This wire has a total resistance of 7 ohms, giving a current consumption of 16 amp. at 110 volts, a total of 1,760 watts. One end of the gas pipe is fastened to one end of the box while the other end passes through the opposite end and connects into a service box. The live portions of the elements do not touch any part of the box.


Signal lamp
Sheet iron box for switch
Resistance wire wound on pipe wrapped with asbestos
Sheet iron box
Asbestos lining

This electrical heater is used to dry shoe soles before buffing. The construction of the heating elements is explained in the accompanying item.

At the terminal ends of the coil a hole is drilled into each gas pipe and insulated with short porcelain tubes. The ends of the wire, insulated with asbestos tubing or insulating beads, are inserted through these tubes into the pipes and run inside the pipes to the service box where they connect to the switch.

In operation the temperature rises to 160 deg. F. at the working surface. The box is capable of drying 1,080 pairs of ladies shoes satisfactorily for good buffing in eight hours. Although this electric heating device has been in use for five years and operates eight hours per day except Sundays and holidays, the heating elements are still in good condition. ALBERT KOCHS.
Chief Engineer,
Hamilton Brown Shoe Co.,
St. Louis, Mo.

What to Do and What Not to Do When a Plating Generator Sparks

A PLATING dynamo of any appreciable size delivers, at times, current amounting to many hundreds or thousands of amperes. If there is sparking at the brushes, a rough commutator will be the result in a short time, which in turn will rapidly wear down the copper gauze brushes. Sparking should not be tolerated any length of time if it can possibly be avoided. When this trouble is encountered and it is not necessary to turn the commutator in a lathe, the best remedy is to remove all the brushes and their holders, drive the dynamo at full speed and proceed to smooth the commutator with a stone.

The best stone for this purpose is one of carborundum (very fine grain) measuring 4 in. long, 2 in. wide, and 1 in. thick. First mark this stone to correspond to the arc of the commutator and then grind

it out on an emery wheel, so that the concave area fits as closely to the commutator as possible. The stone should be ground on its long edge to make it easy to handle.

If the surface of the commutator is lightly wiped with a piece of waste or cheese cloth soaked in kerosene, the copper dust will be removed and the stone will "bite" at once. The stone should be held firmly with both hands and pressed down hard till it cuts, shifting slowly from side to side across the commutator, but not following up and down in the grooves. It will be found that the stone will be copper-coated in a minute or two, but this can be removed with No. 1 or No. 0 glass paper. After a number of repeated attempts at smoothing the stone will cease to copper coat, as the commutator will become rough enough to throw off all the dust.

When the stone heats so that it is unbearable to the hands, simply allow it to cool off, perhaps outside the window, but do NOT USE WATER for this purpose. Continue to cut the surface of the commutator as hard as you can bear down on it, moving slowly sideways, until all grooves are smoothed down, which may take half an hour or more.

When nicely trued then lay a strip of No. 0 or No. 00 glass paper in the concavity of the stone and smooth the commutator till the roughness of the severe cutting has been eliminated. Fifteen or twenty-five strips may have to be used in this treatment. After some fifteen minutes or more a little motor oil should be applied to the glass paper or to the commutator. Then the surface of the copper will begin to smooth up rapidly and begin to look like new. When finished wipe the commutator and clean the holder pins and their insulators on the rocker arm of copper dust.

New gauze brushes may now be set into position. Stagger each successive set sideways from the preceding set, but do not allow them to bear down hard. Much of the trouble from sparking is due to copper brushes having a tension similar to that given carbon brushes. The former are good conductors while the latter are not, thus needing more tension. Copper gauze brushes properly staggered, with fairly light tension; a smooth commutator slightly smeared with vaseline; the rocker-arm set with the brushes slightly leading the neutral point; and the armature shaft having a little end play, will result in a sparkless and cool running plating dynamo.

To keep the commutator in good condition, clean it each morning with thin oil (such as "3 in 1"), and then apply a little vaseline. Heavy oil poured on the commutator, or the application of a greasy compound stick will cause poor contact and sparking if continued daily. When sparking is in full possession such applications are not "cures" but irritators and the operation described must eventually be performed.

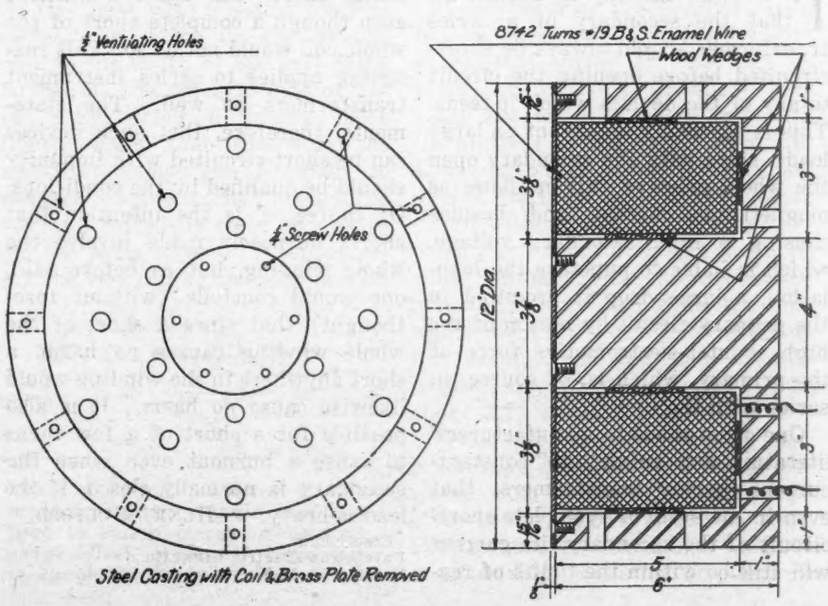
New Britain, Conn. H. S. RICH.

How to Make a Magnet to Remove Stray Iron From Coal

EXCEPT to the man with a good technical education or to those who have made a special study of the subject, the construction of a lifting magnet is always a difficult problem. This is largely because the necessary data is hard to find even in the best handbooks and, when found, it often contains so many difficult formulas that it is hard for most of us to use it. The accompanying illustration shows a magnet which the writer had to design for cleaning coal on an 18-in. belt conveyor before the coal was put into Griffin mills to be ground to powder for use in cement kilns. The Griffin mills have a fine-mesh screen which is easily broken by bolts, nails, washers, or other pieces of iron commonly found in coal. This magnet by removing such stray pieces of iron has cut the screen consumption on eight Griffin mills over 60 per cent, and has paid for itself in less than two months.

The magnet is wound for 125-volt direct current and at that voltage takes approximately 1½ amp. The body is made of a soft steel casting finished as shown in the illustration, with a slight taper which allows the coil to be easily inserted and wedged in. The coil, which consists of 8,742 turns of No. 19 B. & S. gage enamel-insulated magnet wire, was wound on a spool and made of such size as to leave a ⅛-in. space all around between the coil and the iron. The coil was then insulated with two layers of strong cotton tape, half-lapped, and given two coats of shellac. When in place the coil is separated from the iron by ⅛-in. wooden wedges. This allows air to circulate around the coils and a number of ½-in. holes were bored as shown to provide thorough ventilation and cooling. After a 6-hour run the temperature of the coil was 50 deg. C. as shown by a thermometer held against the insulation through one of the ventilating holes. The leads are brought out through two of these holes and run through a fiber terminal block at the back of the magnet. A brass plate ⅛-in. thick holds the coil in place and is secured by eighteen ¼-in. by ½-in. flat-head brass screws. The magnet can be supported by one or more ring bolts, threaded in at the back, depending on the place where it has to be used and the angle at which it must be held. The cost of the magnet was about $70 in material and labor.

Construction details of magnet for removing stray iron from coal or other materials.



No claim is made for perfection of design or high efficiency; likely a much better magnet could be made out of the same material, but it works satisfactorily. It will pick up 6-in. wire nails at a distance of 5 in., or a bar of iron 1 in. square and 12 in. long at a distance of 3 in. Some idea of its strength may be obtained from the fact that it will hold up a piece of 7-in. round shaft weighing 100 lbs. The ability to attract small pieces of iron at a distance of 4 or 5 in., is of course, the feature most useful to us, inasmuch as we had to mount the magnet 4 in. above the belt conveyor so as to allow the coal to pass underneath. It has now been in use for over six months and has given no trouble whatever. The only attention it needs is having the belt conveyor attendant scrape off the nails, washers, bolts, and so on, about once every hour. This is done with the hand and can be done safely without cutting off the power by using a working glove to save the fingers from cuts and also to provide against possible shock from grounds when the conveyor tunnel floor is damp.

J. H. GALLANT.

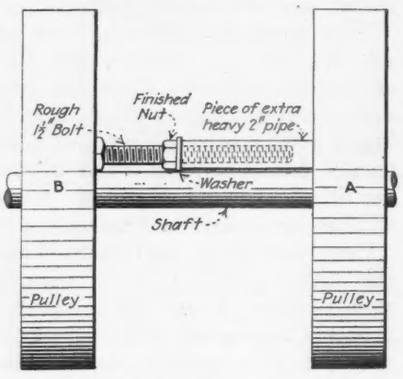
Canada Cement Co., Ltd.,
Belleville, Ont., Canada.

How a Tight Pulley Was Moved on Its Shaft

IT IS often hard to shift a pulley along a shaft, especially if it has been in place for some time. For this reason some methods which the writer has seen tried for moving tight pulleys may be interesting.

A solid-rim pulley on a countershaft resisted all efforts to move it on the shaft until the jack shown in the accompanying drawing was applied. The resistance was probably due to the slight annular elevations on the surface of the shaft under the set screws, aided by the rusted condition of the hub and shaft The jack consisted of a piece of 2-in. double-extra-heavy pipe, a 1½-in. rough bolt and finished nut, and a steel washer about ½ in. thick. The pulley *A* was clamped firmly to the shaft with the set screws. The set screws of pulley *B* were slacked off and the nut of the jack was tightened against the washer. By this means a powerful force was exerted against pulley *B*.

If a solid-rim pulley cannot be shifted along a shaft by ordinary means, and there is nothing to jack against, then the grip of the hub may be loosened by applying heat. This method was used in moving a 40-in. solid-rim pulley a distance of 20 in. along the shaft. An attempt was first made to drive the pulley with a heavy steel bar and sledge. After an hour's steady work the pulley had been shifted scarcely an inch. It was then decided to expand the hub by heating. Four gasoline blow torches were hung from the spokes of the pulley, two at each end, and their flames were allowed to play on the hub for half an hour. The hole in the hub had then been enlarged sufficiently to permit the pulley to be moved by merely butting the hub with the end of the bar.



A tight pulley can be moved along the shaft by means of a jack.
A second pulley, A, was firmly fastened on the shaft a short distance from the pulley to be moved. The jack was then placed between the two pulleys and tightened.

St. Louis, Mo. A. J. DIXON.

Sectional Short Circuit Caused Burn-out of Entire Coil in Series Transformer

IT IS well known, or should be, that the secondary of a series transformer should always be short-circuited before opening the circuit to any of the devices which it feeds. This is especially important on large loads, since with the secondary open the whole primary current flows as magnetizing current and besides causing a high secondary voltage, which is liable to puncture the insulation, a large drop is produced in the primary circuit by reason of the high counter-electromotive force of the primary, which is, of course, in series with the line.

One often reads in manufacturers' literature concerning "tub" constant-current, series transformers, that even in the event of a complete short-circuit of the secondary, its current will still be within the limits of reasonable regulation and will cause no harm, provided the primary voltage is not above its rated normal value. One is liable to naturally conclude that short-circuits are harmless to the transformers mentioned, but such is not always the case.

A few days (or nights, rather) ago, lightning struck on one of our series street circuits, and besides burning out 50 or more lamps, it went by the arresters and blew all of the fuses on our substation switchboard. It also caused a *sectional* short-circuit of the "tub" secondary, and this in turn burned out. This condition was possible because only a fraction of the turns were concerned, and still further helped by the fact that when the lamps burned out the line was opened. The coil contained about 400 turns and with 6.6 amp. (the rated secondary current) it produced about 2,640 amp. turns with which to "buck" the primary coil.

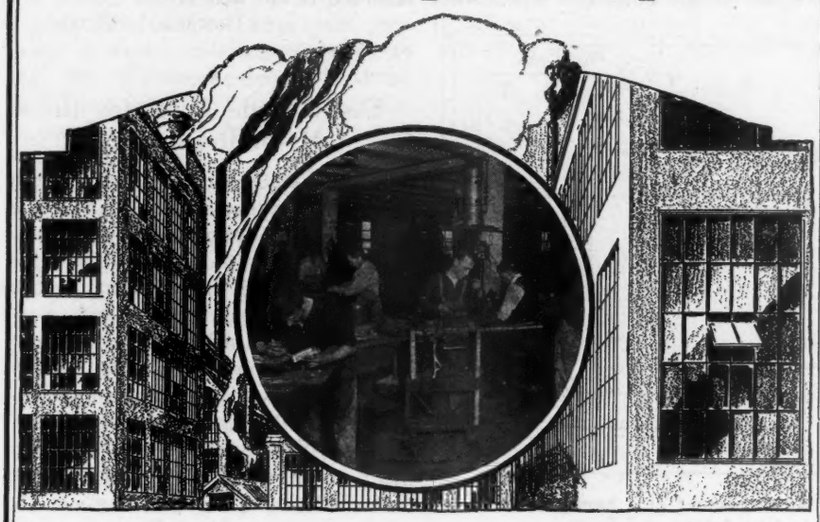
The short took place over just ¼, or 100 turns, which, therefore, had to carry (or attempt to carry) four times 6.6 amp., or 26.4 amp., in order to produce the required amp. turns. No wonder, then, that this section caused their burnout, too, thus destroying the whole coil. No harm was done to the primary coil, because the secondary was repelled hard up against the yoke of the magnetic circuit and was thus quite a distance from the primary coil. The circuit was opened later by a time switch, anyway, and beyond filling the station with smoke, no harm was done by the burnout of the coil.

This experience shows that a "sectional short" can cause a burnout even though a complete short of the whole coil would not do so. This reasoning applies to series instrument transformers as well. The statements, therefore, that such devices can be short-circuited with impunity should be qualified by the conditions. Of course, if is the intention that shorts purposely made involve the whole winding, but as before said, one would conclude (without forethought) that since a short of the whole winding causes no harm, a short anywhere in the winding would likewise cause no harm. It is also possible for a short of a few turns to cause a burnout even when the secondary is normally closed, if the load is heavy.

HENRY MULFORD.

Electrician,
Patchogue Electric Light Co.,
Patchogue, N. Y.

In the Repair Shop



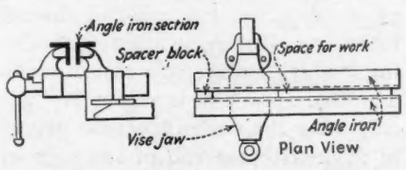
This section is devoted to all sorts of electrical repair work, large and small. Special attention is given to tools found convenient at the shop bench and short cuts or improved methods. Articles on these subjects are always welcome.

Angle-Iron Extensions Enable Vise to Hold Large Parts

MANY repair shops could adopt to advantage the following method of holding long, irregular shaped pieces while working on them. In an iron-working shop where gratings, sheet-steel guards, wrought iron fence work and other similar large parts are worked on, the angle-iron extensions in the vise, as illustrated in the attached sketch, were devised to hold these sections while doing the necessary fitting and attaching of parts, such as hinges, bolting and riveting. These angle-iron extensions are placed between the vise jaws with a spacer block at one end, as shown in the sketch, equal to the width of the part being clamped at the opposite side of the vise. By using a spacer block slightly wider than the work the angle-iron clamps can be made to meet at the opposite end first and the vise jaws pulled up tight enough to hold the parts secure. When necessary the vise can be swiveled around to permit of clamping parts extending 3 or 4 ft. below the vise.

This extension is also applicable to sheet-iron and sheet steel work, as it is a simple device which can be easily prepared. G. A. LUERS.

Washington, D. C.

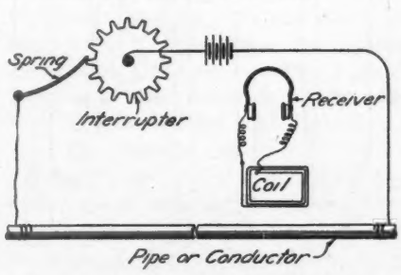


Wide extension jaws for a vise made from heavy angle iron and used to clamp pieces of unusual shape which ordinarily could not be caught in the bench vise.

Exploring Coils Simplify Work of Tracing Conductors

TRACING conductors, which includes all kinds of metallic piping as well as electric cables, is often difficult and accomplished only by considerable work and expense. A set of wireless telephone receivers connected to the proper exploring coil can, however, frequently be used to good advantage in such work with a resultant saving of time and expense. For example, about two years ago we were confronted with the problem of finding a T in an underground water main. Several short ditches were dug in order to locate it, but without success. Then an exploring coil about 4 ft. long and 3 ft. wide, wound with approximately fifty turns, was used while the pipe was excited with 500 volts alternating current and the joint located within a short time, although it was about 6 ft. beneath the ground.

While this may be one of the most practicable examples of using an exploring coil, I believe there are many other cases where it could be used. For instance, in long cables where it is undesirable to disturb or puncture the insulation as required for voltmeter tracing or where the cable or conductor is not accessible for making contact, like the neutral in a three-wire direct-current machine, in the bottom of the slot beneath other coils. It might also be used to tell if current is flowing in any alternating conductor where ammeter connection is impracticable or where there is leakage current through an iron structure or even to determine trouble with an alternating current motor; for instance, without disturbing connections, to find out whether the motor is taking current in all phases and whether the current in all phases is approximately the same. The exciting current required as well as the size of the exploring coil may vary greatly in extreme cases. From my own experience I find that the exploring coil should vary in size with the distance it is held away from the conductor. Thus it is possible to use a 1-in. coil when it can be held close to a small cable, as in the case where it is desired to pick one cable out of a bunch of similar cables, and as large as 3 ft. or more where the distance between the exploring coil and the pipe or other conductor is several feet, as in underground work. The exploring coil should be rectangular in shape, especially in the smaller sizes, so that one side of the coil can be placed parallel to the conductor to be traced. Any insulated, fine wire will do for the coil but as a rule the small coils should be wound with finer wire and with a larger number of turns, so as to get sufficient induced emf. About three sizes of coils will cover the entire range fairly well, using a 1-in. coil of 400 to 500 turns of No. 30 to No. 36 B. & S. wire for small work, a 4-in. by 8-in. coil of 500 turns for larger work and a 3-ft. coil wound with 40 to 100 turns of No. 20 to No. 30 B. & S. wire for underground work. The more turns a coil has the less exciting current is required. In all cases the ends of the coil should be connected to the receivers.



Here is a simple way of obtaining an interrupted current for testing with an exploring coil.

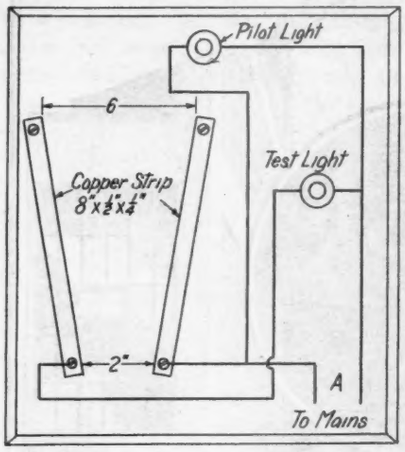
The section of piping or cable to be traced must, of course, be excited by a current of a frequency which is audible in the receivers. Such a current can easily be induced in any conductor in several ways. In an underground pipe one end of the pipe may prove sufficient for exciting it for some distance but, of course, if connections can be made at the two extreme ends by an outside circuit, it is far better. Where cables run through iron piping the exciting current must be sent through the pipe instead of the cables. For producing the exciting current a high-frequency generator is best but if such a machine is not available, current from a battery or other source may be used with an interrupter placed in the circuit so that the current flowing will be varied or interrupted and thus produce an audible noise. The accompanying illustration shows a simple and satisfactory method of obtaining an interrupted current suitable for testing purposes. As will be seen, the device employed for this purpose consists of a gear wheel on which a flat spring presses so as to snap from cog to cog and thus make and break the exciting current as the gear revolves.

PHILIP BERNHOLZ.

East Orange, N. J.

Inexpensive Board for Testing Lamps and Fuses

THE ACCOMPANYING diagram shows the arrangement of a board which I have found very convenient for testing lamps or any length or size of fuse. The material required for this board is inexpensive and comprises two ordinary porcelain lamp sockets, two pieces of copper strip 8 in. by ½ in. by ¼ in., and some No. 14 wire. The copper strips should be screwed to the board 6 in. apart at the top and 2 in. apart at the bottom. Where the wires are connected to the copper strip it is advisable to use end terminals of the flag type, screwed down tight to avoid the possibility of sparking or heating. The test lamp is in series with the strips and when a fuse is placed between them the lamp will light, provided the fuse is in good condition. The pilot light may be left out if the board is in a well-lighted position, but I think that it is advisable to use a pilot light inasmuch as it always shows whether current is flowing through the board.



Arrangement of a handy board for testing lamps and fuses.

A single- or double-throw single-pole knife switch may be inserted at *A* if it is desired to open the circuit of the board when not in use. If series lamps, or lamps of half the ordinary voltage are used in the factory, two sockets in series may be used in place of the single test light, and when only one socket is required for testing, a 3-amp. fuse may be inserted in the other.

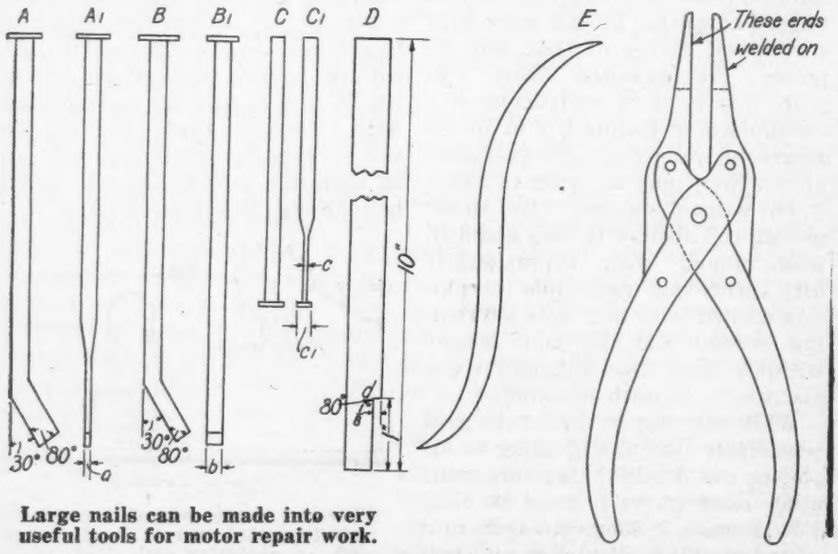
DONALD L. HOARE.

New York City.

Easily Made Tools for the Motor Repairman

THE ACCOMPANYING sketch shows a few easily made tools which I have found to be very useful on motor repair jobs. The first three, *A*, *B* and *C*, can be made in a few minutes from 6-in. and 4-in. wire nails with a hammer and file.

The tool shown at *A* is for removing wooden wedges from small motors, 5 or 10 hp., with semi-closed slots. About one inch of the nail is bent at an angle of 30 degrees and flattened out with the hammer to approximately the thickness required; it can afterward be finished with a file. The thickness of the driving blade *a* must be such that it will just pass freely between the overhanging tips of the armature teeth. An angle of about 80 deg. has been found best to prevent tool from slipping off the wedge when being driven with the hammer. The tool *B* is made much the same as *A* except that the thickness of *b* of the driving blade is made greater, as the tool is intended for removing wedges from open slots. Tool *C* is made from a 4-in. or 5-in. nail, and is used for packing wires snugly in semi-closed slots. The nail is filed flat next to the head and is left just thick enough to slip easily between the overhanging tips of the armature teeth; the head is narrowed down so that it will just move freely inside the slot insulation. When two or more wires are placed in the slot a piece of tough fishpaper the width of the head of the tool is placed on them to protect the insulation from abrasion and the wires may be packed by gently tapping the tool with a hammer, or even by hand pressure. The tool *D* is for driving in wooden wedges. It can be made as shown in the sketch by filing a piece of ½ in. key steel or an old rotor bar. It can be used for driving wedges either on a stator or on a wound rotor; it is meant for use only after the wedge has been driven in flush with the end of the coils or of the rotor bars. At *d* the tool should be filed in to an angle of about 80 deg. to prevent slipping off



Large nails can be made into very useful tools for motor repair work.

the wedge. When driving, the thin part of the tool which is kept over the wedge holds the latter down against the coils or bars and prevents it from buckling and breaking. The dimensions given for these tools are approximate, and they can and should be fashioned to suit individual needs.

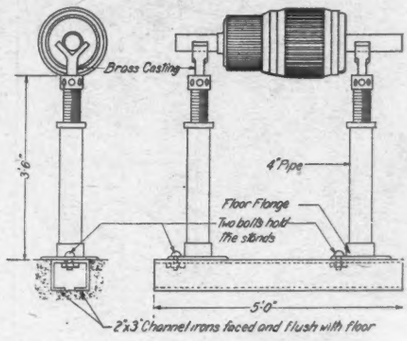
At *E* is shown a small cotter pin extractor with one end flat and one end round and tapered to a point. This makes as good a taping hook as can be found. The pliers shown in the last sketch cannot be bought as illustrated, so far as the writer knows. They are made out of an old pair of 6-in. Bernard parallel pliers by welding about one inch on the ends. When wound with one layer of friction tape they make a very handy tool for getting formed coils into the slots. Formed coils are often more or less twisted, and can seldom be put in without some twisting and pounding. With the help of these pliers, the flat points of which are thin enough to slip in between coils, it is possible to hold and pull a twisted coil parallel to the slot and thus put it in without cutting the insulation on the corner of the slot, the point where it is most often injured. Likewise as the jaws of the pliers are parallel and taped they will not injure the coils.

J H. GALLANT.

Canada Cement Co., Limited,
Belleville, Ont.

Adjustable Support for Rotors Facilitates Winding

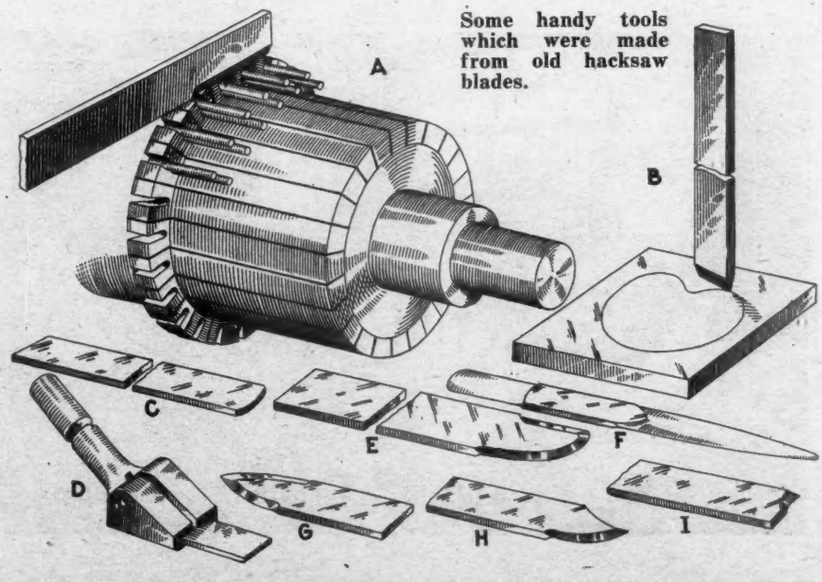
USE OF an adjustable stand to support rotors while rewinding them has greatly facilitated this work in the repair shop of the Old Dominion Copper Company. The accompanying illustration shows a support which was made entirely of material available around the shop, with the exception of the brass tops which were cast for the job. As is shown, the height at which the rotor is supported can be adjusted by means of the screws. The distance between the legs is varied by sliding one of the legs along the channel-iron base. It has been found that even a few inches difference in the height of a rotor which is being rewound may add much to the comfort of the winder and the speed at which he can do the work. As this work is often of an emergency nature opportunities to speed it up should not be overlooked. The ease of turning the rotor to a new position is another advantage over using a bench while winding. Also, a rotor wound in this way is in no danger of injuring the coils when turning it as might happen if it were lying on a bench.



Convenience and speed of winding are greater with an adjustable rotor support like this.

STEPHEN TILLMAN.

Chief Electrician,
Old Dominion Copper Co.,
Globe, Ariz.



Some handy tools which were made from old hacksaw blades.

Useful Tools Made From Old Hacksaw Blades

IN EVERY shop there is usually a lot of broken or worn-out hacksaw blades which will make handy tools. They need only to be ground to shape and, if they are too hard, have their temper drawn. For use in the electrical repair shop, blades ground sharp make good tools for cutting the ends of conductors at the commutator as shown in drawing *A*. The thinness of the edge makes it cut with light blows of a hammer, so that the commutator bars are not knocked down. Some of the other shapes shown may be used to clean surfaces, to skin wire, and to do general service in the kit.

For the machine shop large blades ground like *C* make good single- and double-end scrapers. These blades are fine for light work and especially for removing accumulations from the ways of machines which have been idle for a time. Sometimes short blades can be put into a holder like *D* to good advantage.

To make a tool useful to a pattern maker, take a power hack-saw blade, grind the teeth off and shape the end like *E*, sharpening it all the way around. This makes a good knife for reaching inaccessible places around the pattern. At *B* is a blade ground like a skew chisel and used for tracing lines for inlay work. By holding the upper end of the chisel with one hand and tapping it with a hammer one can work out any shape. At *F* is a double-ended palette knife good for mixing or spreading color, glue, putty or plaster of paris. If the blade is ground thin enough to have a good spring it is excellent for palette knife painting.

For the drafting room, *G* is a light blade from a band frame with the teeth ground off, sharpened on each edge for sharpening pencils, cutting paper and scratching out ink. At *H* is a better point for opening up the centers of letters such as *o*, *e* and *a* when they clog and also for sharpening corners and intersections of lines. At *I* is a shape for cutting along a straight edge. Only a small portion of the blade is sharp; the rest is left dull so that it will not spoil the straight edges.

Sometimes it is convenient to grind one of these forms on each end of the blade. If a handle is desired it can be made by wrapping the blade with electrician's tape and giving it a coat of shellac. Many prefer the flat blade, however, as it will not roll.

Detroit, Mich. NELSON HALL.

Better ways to transport and handle raw and finished parts in and around the works will be discussed in this section.

Flexibility of Movement by Either Hand or Tractor Increases Utility of a Truck for Shop Haulage

IN ANY material handling system, the units of equipment are more effective if flexible. For this reason whenever material handling equipment is so constructed that it can be moved both by hand or by other devices, it is usually of greater usefulness in the shop. One such example is the special two-wheeled box truck, shown in the accompanying illustration, of which many are used in an automobile plant. Each of these trucks has a special casting fitted on the front as shown. A special handle with a wheel and a pivot point may be fitted into this and by pushing down on the handle made to support the front end on the wheel instead of on the leg, as shown here, and the trucks can be pulled by hand. Also, this special casting fits into a coupling which fastens these box trucks together so that they may be used as trailers, in a train. Here one tractor makes regular 30-minute runs between the rough stock room and the machine shop. Material handling on a regular schedule such as this does much to prevent many tie-ups in transportation.

Frequently it is feasible to make a truck or container which may be handled in a third way. For example, in this instance the side pieces of the box truck are extended at the end in such a way that they may be lifted by a four-chain sling and an overhead crane, thus adding to the flexibility of the unit. Another plant has designed its containers so that they may be moved by hand, by power or hand-lift trucks or by crane. The skid is provided with rings at each corner for lifting by the crane and with wheels so that it may be pushed about.

Trucks that may be moved by hand, or by tractor or crane increase the ease and speed of movement of materials.

One of the objections to stationary trucks is that they cannot be moved without the tractor. Men on production do not want to wait. Here the box truck can easily be moved by a simple pivoted handle and wheel. For long hauls the trucks are coupled up into trains hauled by an electric tractor. Also with extensions on the side pieces, as here, the crane can pick one truck out of a group with a sling if it should become necessary to store a number of trucks together.

Signal Board to Notify Move Men of Loads Ready or Empty Trailers Wanted

ONE problem which must always be considered in any inter- or intra-departmental haulage plan is that of making some provision for signaling to the move men when loaded trucks and trailers are ready to be moved. This is particularly true where loads are ready intermittently at the various stations. This problem was one of the first encountered when a tractor-trailer installation was placed in the freight house of the Norfolk and Western Railroad at Roanoke, Va. Here an early problem was to devise some method whereby loaded trailers, which would be placed unexpectedly at a point on the platform out of the usual path of the tractor travel, would be hauled away so as to avoid congestion. In order to call a tractor to one of these points it was necessary at first to send a man to hunt until he found the first available tractor crew. This was unsatisfactory.

To remedy this the electrical department worked out a simple and effective system of signal lights to notify the tractor crews automatically when and where their services were required. A battery of green and red electric lights, with a light of each color placed by the side of a set of numerals, each of which designates a main division of a platform, was mounted on a board where the tractors in their regular duties pass it on each trip. A red light means that loaded trailers are ready to be moved and the number beside the red light indicates where the loads are to be found. A green light beside the numeral indicates that empty trailers are needed at the point des-

ignated by the respective numeral. A glance at the board to see which lights are on tells the tractor crew where empty trailers are needed and where loaded trailers are waiting to be hauled away. The tractor crew is then able to take either a train of empty trailers to the spot where it is required or go with the tractor and haul away a loaded train.

Each pair of lights is wired to switch boxes, with a button for red lights and another for green lights, located on prominent posts along the platform in the sections denoted by the corresponding numerals and so are convenient to the checkers supervising the loading or unloading of freight cars. A pilot light shows the checker what signal he has set. As soon as the tractor crew reports to the checker in response to signal, he switches off the button so that another tractor crew will not report on the same signal. The pilot light makes it less likely that he will forget to turn the lights off than if he used an "on" and "off" indicator. In addition a master re-set switch controls the entire system so that the foremen during the lunch hour or after the day's work can extinguish all the signal lights from a central point.

Protecting Truck Platforms From the Heat of Hot Forgings by a Special Box Skid

ONE OF the biggest problems in connection with the operation of either electric storage battery or hand elevating-platform trucks is in the choice of the most effective skid. This was solved in one plant by the special box skid shown in the accompanying illustration. Here the problem was to handle hot forgings. The box skid is made up of heavy plate and angles as shown. The hot forgings, however, would warp an ordinary plate bottom to this box skid. The heat also would be transferred through to the steel platform of the elevating trucks and if it was necessary to haul the load any distance might warp it also.

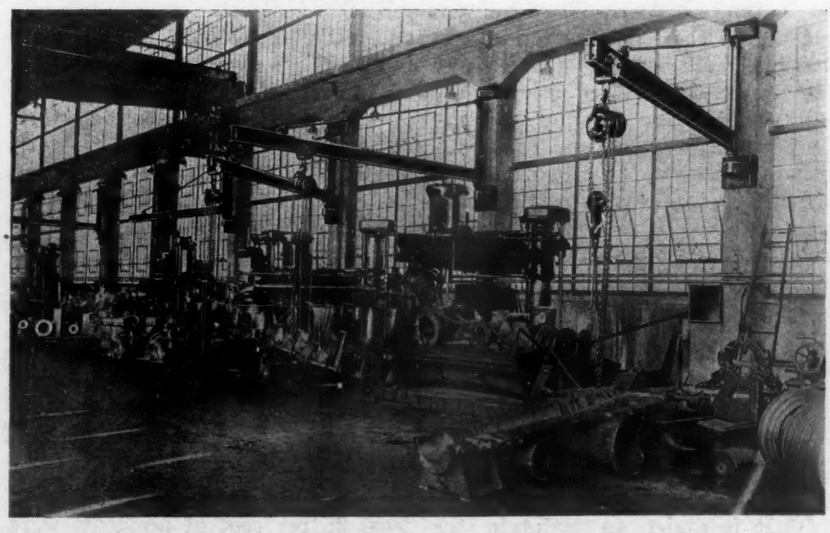
To overcome this difficulty steel tubes, open at the end, were used in the bottom as shown. By the circulation of air through these the heat was dissipated sufficiently so that it did not affect the electric truck. The tubes, also, support the plate-steel bottom of the box skid.

Hot forgings are handled by this truck skid without danger of warping the platform of the truck.

By attaching these tubes to the bottom of the box skid the heat from the hot forgings is carried away so that it is not transferred to the platform of the truck. This truck installation in a large forging plant was made by The Elwell-Parker Electric Company, Cleveland, Ohio. One man with a truck of this sort can handle loads up to 4,000 lbs. at a rate of about 6 miles an hour.

Swinging Jib Cranes Relieve the Traveling Crane of Miscellaneous Handling

ONE OF the easiest ways of tying up an overhead traveling crane for long periods is to require it to do the handling of large pieces to and from the machines or during assembly. One of the prime purposes of a traveling crane is to lift and carry heavy loads for some distance, instead of making a short lift or an adjustment. Where there is much of this work, it is often economical to add jib service cranes (Whiting Corporation, Harvey, Ill.) as shown in the accompanying illustration. These are attached to the wall and the boom swings around over the machine and covers considerable floor area. These are made in capacities of ½ to 2 tons, for ordinary service. The I-beam jibs carry trolleys which support chain blocks or air or electric hoists. Where work is moved frequently, on or off the machines, it usually pays to use a power-driven hoist.



Service jib cranes handle work to and from machines instead of waiting for the overhead traveling crane.

The machines in this engine-building shop do not have to take their turn in waiting for the overhead traveling crane as each machine is served by its individual hoist. Similar equipment can be used to the same advantage in assembling heavy machinery and often in stock rooms handling heavy parts. This equipment is out of the way and does not interfere with the regular operation of the traveling crane. Also the operator of the machine can use it without assistance.

Operation and Management of the

Medium-Sized Plant

Was the Main Topic Discussed at the Meeting of the Society of Industrial Engineers at Cincinnati, April 18 to 20

By FRANK E. GOODING
Associate Editor, Industrial Engineer

DUE TO the changing industrial conditions it was quite fitting that the major subject which was discussed at the Tenth National Convention of the Society of Industrial Engineers in Cincinnati, Ohio, on April 18, 19 and 20, was "Effective Management for the Moderate-Sized Plant." Particular emphasis was given to the problems of the moderate-sized plant, that is, those employing between 20 and 500 men. In times past, most of the attention to the control and operation of management and production has been devoted to what has been commonly called the larger plants. The wealth of our country lies in the development of our natural resources. It is the work of the minds of the management to make more effective the work, methods and processes so that the men can effectively increase production from the effort put in. As the large plants produce about two-thirds of the total value of manufactured products and employ about half of the men, while the smaller plants produce one-third of this total and also employ approximately the other half of the workers, it is easily seen that there are wide opportunities for improved management and operation to get the value of production per man more nearly equal in large and small plants. Thus it was fitting that Joseph W. Roe, president of the Society, took as his subject, "The Need of Management Methods in the Moderate-sized Plant." In part, Mr. Roe said:

"Out of 290,105 manufacturing establishments reported by the United States Census in 1919, there were only 1,021 or less than 0.4 per cent, which employed more than 1,000 wage earners; and only 2,770, or less than 1 per cent, employing over 500. There were 235,884, or 81.3 per cent which employed 20 or under, but they represented all told, only 10.3 per cent of the wage earners, and an even smaller percentage of the production. The remaining plants, namely those employing between 20 and 500 wage earners, number 51,451 or 17.7 per cent of the total, and represent 50.1 per cent of the total wage earners.

"The advantage of the large plant over the small one lies chiefly in the field of purchases and sales. In actual production the small plant can frequently compete with the large one on even or better terms. Certain industries are by nature monopolies and under proper regulation should be operated as such. In others, such as refineries, steel and flour mills, production is more economical when carried out on a large scale. There remains, however, a large field of industries where quantity production is not essential and quality is important. In this field the small plant is able to compete and has certain distinct advantages.

"(*a*) To a large degree, the actual managers of the small plants are the owners, with a keen and vital interest in the operation. They can act and adjust their policies quickly to changed conditions. (*b*) The owners and the employed force are in close daily contact, and so know and understand each other. (*c*) The influence of a keen, magnetic personality at the top can permeate the whole plant, and not have to filter through a set of officials to reach the workmen. Generally the small plant has less labor trouble. (*d*) The operations of the small firm are usually confined to one plant and may be carried on by direct personal contact, with freedom from red tape and internal correspondence. (*e*) Because of the above, the overhead is frequently less than in the large plant. (*f*) It is easier to maintain the spirit and atmosphere of quality.

"Something is sacrificed from practically all of the above elements with increasing growth. Growth usually comes by development into manufacturing as distinct from building or special order work. It is hard, however, for the small firm to resist pressure from customers and salesmen for special modifications in design, and for promises of delivery which can only be kept by an endless procession of rush orders, which wreck any consistent production program. But growth as a rule depends on concentration upon such a program and on standardization of product. Growth depends on wise provision for extension of both plant and organization. Provision for future physical growth is more common than for development of the organization. More owners can show you where they plan to put their next building, than can tell you who is in training to head departments they plan to add in the next few years. The personnel of the small plant should be chosen with growth in mind. The big plant can get and pay for a big man who has already arrived. The small plant must raise him. The small growing concern which selects, trains and coordinates its force into a smoothly working unit is building up an asset which gives it an immense advantage over any new competitor, however large."

One important difference between the large and small plant, as pointed out at one of the meetings, was that the small plant conserves material at the expense of time while the large plant conserves time often at the expense of material.

In the Friday afternoon meeting, particular emphasis was given to the subject of "Health and Industry," under the direction of the Industrial Health Conservatory Laboratories, of which Dr. Carey P. McCord is director. One of the discussions took up the subject of "Lighting—Good and Bad." The speaker pointed out that it had been established that good lighting had increased production 10 per cent. Also, that about 25 per cent of products were made under artificial light and that a large percentage of poor quality work could be chargeable to bad lighting. It has also been shown that at least 20 per cent of preventable accidents are due to insufficient illumination. This is considerable improvement because, not many years ago, at least 25 per cent of accidents were due to the same reason.

Servicing Industrial Transmission Belts

(Continued from page 256)

high speed, metallic fasteners or laces work satisfactorily.

Methods and Materials Used in Dressing Belts

Manufacturers and belt users do not always agree as to the proper belt dressing to apply. Each manufacturer recommends certain dressings for his belts and these should be considered. Belt dressings are applied, in general, for two purposes: Either to soften the belt and lubricate the fibers to reduce wear due to the continual bending action as it goes over the pulley and straightens out, or, to prevent slipping. For leather belts the manufacturer's dressings usually consist of animal greases or oils similar to those used in currying belts during manufacture. (Currying is a process for replacing in the belt the natural, animal oils which make a belt soft and pliable.) Belts are dried out by the action of the air, get hard and crack. Natural, animal oils are probably the best lubricants for these fibers as they are most near to the natural lubricant in the original hide. Belts which have stood idle for some time should be dressed to soften them up before placing back in use. Double- and three-ply leather belts should be treated on the outside as well as on the side next to the pulley when dressed.

One of the more common of the practical shop-man's applications consists of two parts of beef tallow (inedible) mixed with one part of cod liver oil. The oil is added to the melted tallow after it has cooled slightly and stirred until cold. It is applied with a light brush, but care must be taken not to use more than the belt will absorb. Neatsfoot oil is also often used in working dried-out belts into shape.

Belts used in dusty, dirty places or where dressings have been used in excess and have dried or caked on the surface of the belt, should be cleaned before dressing. Leather belts may be cleaned by washing or scrubbing with a brush in a cleaning mixture composed of two parts of gasoline or naphtha and one part of turpentine. This mixture must not be used on rubber or Balata belts. Also, a high-grade naphtha or gasoline must be used as low-grades of these oils leave the belt greasy. This softens the dirt so that it can be scraped off with any metal straightedge not sharp enough to cut. If one treatment is not enough it should be repeated and the belt dried before applying the dressing. Methods of cleaning belts when they are very dirty or oily will be described in the next article.

Rubber or Balata belts may be treated by the preparations recommended by the manufacturers of the belts, or, by a few drops of castor oil applied to the pulley when revolving and allowed to spread from it onto the belt. A light application of raw linseed or castor oil may be used on canvas belts. Woven cotton and camel's-hair belts, particularly if specially treated, should be dressed as recommended by the manufacturer.

One of the greatest dangers in the use of belt dressings lies in their use to excess. If more dressing is given than the belt can absorb, the surplus remains on the surface of the belt and collects dust. Sometimes it works up into a lump on the belt or the pulley. In such cases, clean the belt as described, scrape off the pulley and re-treat, using less dressing. Careful and proper dressing does much to prolong the life of belts.

Particular caution must be given against using mineral oil dressings, especially on rubber or Balata belts, and rosin or laundry soap as dressings or to stop slipping. Rubber, Balata and untreated canvas belts are easily ruined by mineral oils. It also decreases the effectiveness of leather belts, but they can be cleaned and treated to make them almost as good as new.

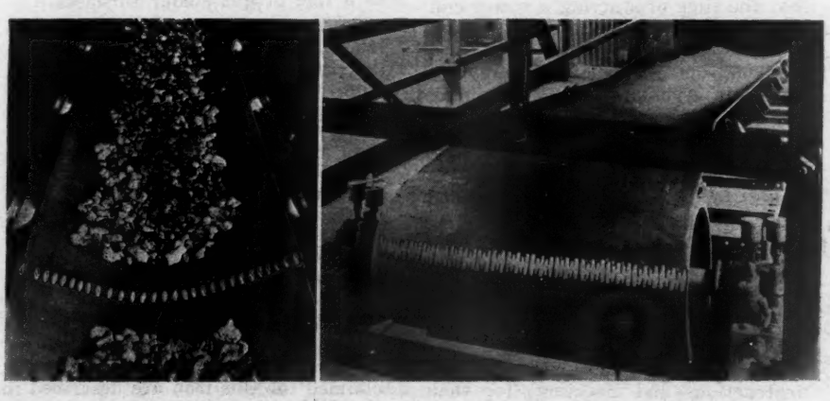
There is a number of dressings on the market which in addition to treating or lubricating the fibers of the belt, also prevent slippage on the pulley even though the belt is run quite slack. Care, however, should be exercised to see that an excess is not used.

Records Which May Be Used for Keeping Track of Belts

Many concerns little appreciate the advantages which come from emphasizing the importance of proper inspection and supervision of belt systems. In many instances belt maintenance costs have been cut in half through proper attention. This saving is small, however, compared to the much larger economies possible due to decreased idleness necessary for belts to be repaired. These savings often amount to several times the cost of making the belt repair.

An important part of any inspection routine is proper records of what has been done. Without these, belt inspection is a hit-and-miss proposition. Adequate records also point out any belts which are not up to quality. Without some such records, one is reproduced with this article, it is almost impossible to make a real comparison of two kinds or grades of belts. Even then the work on other operating conditions must be comparable. After a belting system is once placed in first class shape it is much easier to keep it in condition.

A later article in this series, which will appear in an early issue, will take up the belt reclamation which may be done in an industrial plant. The author wishes to acknowledge special assistance from Louis W. Arny, secretary, The Leather Belting Exchange, J. R. Hopkins, Chicago Belting Company, R. C. Moore, Chas. A. Schieren Company, M. W. Edgar,



Here two types of steel lacings are shown on a conveyor belt.

The belt at the right is joined by a staggered lacing made in short lengths so that it does not interfere with the cupping of the conveyor belt. The belt at the left has a somewhat different type of lacing in that each is individual. Both of these are Bristol metallic lacings.

Detroit Belt Lacer Company, and R. H. Whitney, The B. F. Goodrich Rubber Company, in the preparation of this and other articles which have appeared in this series on belts for industrial purposes.

EDITOR'S NOTE: Acknowledgement is made to the following companies for assisting in furnishing information and photographs for this and the other articles which will follow in this series: The Leather Belting Exchange, 119 S. Fourth St., Philadelphia, Pa.; E. C. Atkins & Co., Indianapolis, Ind.; Victor Balata & Textile Belting Co., New York, N. Y.; Birdsboro Foundry & Machine Co., Birdsboro, Pa.; The Bristol Co., Waterbury, Conn.; Chicago Belting Co., Chicago, Ill.; Cling-Surface Co., Buffalo, N. Y.; R. & J. Dick Co., Inc., Passaic, N. J.; Detroit Belt Lacer Co., Detroit, Mich.; Detroit Oak Belting Co., Detroit, Mich.; Flexible Steel Lacing Co., Chicago, Ill.; The Gandy Belting Co., Baltimore, Md.; The B. F. Goodrich Rubber Co., Akron, Ohio; The Goodyear Tire & Rubber Co., Akron, Ohio; The Graton & Knight Mfg. Co., Worcester, Mass.; Hide Leather & Belting Co., Indianapolis, Ind.; Imperial Belting Co., Chicago, Ill.; Jewell Belting Co., Hartford, Conn.; Laurence Belting Co., New York, N. Y.; Manheim Mfg. & Belting Co., Manheim, Pa.; New York Rubber Co., New York, N. Y.; J. E. Rhoads & Sons, Wilmington, Del.; W. H. Salisbury & Co., Chicago, Ill.; Chas. A. Schieren Co., New York, N. Y.; Stanley Belting Corp., Chicago, Ill.; The Strong Machinery & Supply Co., New York, N. Y.; The Taylor Belting Co., Indianapolis, Ind.; United States Rubber Co., New York, N. Y.; I. B. Williams & Sons, Dover, N. H.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of the bulletin or catalog desired, as given in these columns.

American Injector Company, Detroit, Mich.—A small booklet describes "Agrilite" bearing metal. This is claimed to be a self-lubricating metal with high tensile strength and hardness to withstand bearing pressure, made of bronze alloy consisting of copper, tin and lead. The results of various tests of this metal are included as well as letters from numerous users.

Detroit Belt Lacer Company, Detroit, Mich.—Folders describe the "Detroit" closing machine for lacing belts. This is a flexible steel belt lacing with staggered hooks. These are closed by a special bench machine or by a piece of equipment which fits into a vise.

Sampson Axcess System, Lynn, Mass. —Catalog 2 describes the Axcess ceiling, wall and bench fixtures as well as stationary lighting attachments for machines. This is a special method of getting the lamp and its reflector placed in the proper position for work without interfering with the operator.

The Lester Company, Fayetteville, N. Y. —A small folder describes an aluminum solder and flux for soldering aluminum. Operating instructions are given to show how it is used.

The United States Graphite Company, Saginaw, Mich.—Special booklets and catalogs describe the various grades of graphite paint for different types of protective work. Several pages are devoted to a discussion as to why graphite paint should be used for protective coatings. Among the items discussed are the covering power, the estimation of the quantity needed, and specifications for graphite painting.

McGill Manufacturing Company, Valparaiso, Ind. — A small folder describes the new thumb-switch portable lamp guard. This guard has a hardwood handle, a hook and a reflector. The switch is operated by the thumb while in the natural position to hold the lamp.

Driver-Harris Company, Harrison, N. J. —Data book R-23 entitled "Alloys for Electrical Resistance" devotes over 50 pages to the description of the various Nichrome and other alloy wires for electrical resistance. Over half of this book is devoted to tables and charts as well as curves giving technical data on the various resistance wires. Among the subjects covered are: temperature resistance curves, current temperature characteristics, the resistance of the various wires, and much other useful data.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.— Recent literature describes the new automatic auto-starter for squirrel-cage induction motors. This can be adapted for remote push-button control or for full automatic operation, without the presence of an operator. The control relay is given a definite time limit by means of a dash pot so that the time of starting a motor can be adjusted for any period up to a maximum of 15 seconds.

The Thompson Electric Company, 226 St. Clair Avenue N. E., Cleveland, Ohio—A small folder describes "Glasbrite," a chemical cleaner for dry cleaning and polishing in one operation reflectors, windows and skylights for factories, foundries, and other industrial plants.

Robertson Chemical Company, 9808 Meech Avenue, Cleveland, Ohio—A 24-page catalog is devoted to the Walpole electric insulating compounds. This book not only describes the various liquid, plastic and solid insulating compounds, but also gives instructions and directions for their use.

J. E. Rhoads & Sons, Wilmington, Del. A 64-page pocket-size booklet entitled "Belt User's Book" gives rules, suggestions and other information for belt users. Particular attention is given to splicing, lacing, and other similar treatment of leather belts.

Flexible Steel Lacing Company, 4607-31 Lexington St., Chicago, Ill.—A 72-page pocket-size booklet entitled "Short Cuts to Power Transmission," which is a handbook for belt users, describes the various types of belts, their care and the method of lacing. Particular emphasis is placed upon the use of the various sizes of "Alligator" flexible steel belt lacing. A large amount of belt users' information is included in this catalog.

The Esterline-Angus Company, Indianapolis, Ind.—Bulletin No. 223, which is one of a series of monthly bulletins, issued by the company, is entitled "Some Things Being Done With Graphic Instruments." This Bulletin illustrates a number of graphic instrument installations and shows what uses are being made of them in various industries and commercial plants.

United States Rubber Company, 1790 Broadway, New York City—A 70-page pocket-size booklet entitled "Belting" gives valuable information to the belt user on rubber and canvass belts. This is divided into three sections, which take up transmission belting, conveyor belting and elevator belting. In addition, a number of pages is devoted to miscellaneous tables of value to belt users.

Cling-Surface Company, 1032 Niagara Street, Buffalo, N. Y.—A group of folders describes the advantages and applications of "Cling-Surface" belt preservative in various lines of industrial plants.

The Borden Company, Warren, Trumbull County, Ohio—Catalog 16 describes the Beaver line of pipe cutting and threading tools. With these dies threads for several different sizes of pipe, for example, on one die head threads for 1 in., 1¼ in., 1½ in. and 2-in. pipe are cut without changing the dies or bushings. In addition, a special method of cutting a tapered thread which is explained in this catalog gives, it is claimed, much easier operating conditions so that it is stated one man can thread 8-in. pipe.

L. B. Allen Company, Inc., 4519-29 North Lincoln Street, Chicago, Ill.— A folder describes the Allen gas soldering tool with assorted tips, as well as a line of gas solder furnaces.

E. B. Bronson and Company, Blue Island, Ill.—Special folders describe the Bronson electric lantern, operated from a battery, for watchman, railroad and other similar service. This lantern is made in six different types, each of which is described in this folder. Additional literature describes the Bronson rechargeable storage battery and recharge rack for use instead of dry cells in this electric lantern.

Rohne Electric Company, Inc., Minneapolis, Minn.—A folder describes the "Sta-Warm" soldering iron. In this, the switch for the current is placed in the handle. The advantages claimed for this iron are described in the folder.